A CORRELATION STUDY BETWEEN ACHILLES TENDON CONTRACTURE AND POSTERIOR TIBIAL TENDON DYSFUNCTION ON ANKLE INSTABILITY AMONG YOUNG ADULTS WITH PES PLANUS

SEE WAN NI

BACHELOR OF PHYSIOTHERAPY (HONOURS)

UNIVERSITI TUNKU ABDUL RAHMAN

DECEMBER 2022

SEE WAN NI
A CORRELATION STUDY BETWEEN ACHILLES TENDON CONTRACTURE AND POSTERIOR TIBIAL TENDON DYSFUNCTION ON ANKLE INSTABILITY AMONG YOUNG ADULTS WITH PES PLANUS
2022

(This page is intentionally left blank)

A CORRELATION STUDY BETWEEN ACHILLES TENDON CONTRACTURE AND POSTERIOR TIBIAL TENDON DYSFUNCTION ON ANKLE INSTABILITY AMONG YOUNG ADULTS WITH PES PLANUS

By

SEE WAN NI

A Research project submitted to the Department of Physiotherapy,

M. Kandiah Faculty of Medicine and Health Sciences,

Universiti Tunku Abdul Rahman,

in partial fulfilment of the requirements for the degree of

Bachelor of Physiotherapy (Honours)

December 2022

A CORRELATION STUDY BETWEEN ACHILLES TENDON CONTRACTURE AND POSTERIOR TIBIAL TENDON DYSFUNCTION ON ANKLE INSTABILITY AMONG YOUNG ADULTS WITH PES PLANUS

Deepak Thazhakkattu Vasu[1]
See Wan Ni[2]
Author Affiliation
1. Assistant Professor, Faculty of M. Kandiah Medicine and Health Sciences, Department of Physiotherapy, Universiti Tunku Abdul Rahman, Malaysia.
2. Bachelor of Physiotherapy (Honours) Student, Faculty of M. Kandiah Medicine and Health Sciences, Department of Physiotherapy, Universiti Tunku Abdul Rahman, Malaysia.

Address all correspondence to Dr Deepak at: deepak@utar.edu.my

Abstract

....

Background and Objective: Stability is a complex motor task and ankle stability is vital in maintaining the balance of our body. However, the defect of the foot arch, pes planus is found to compromise the ankle stability. The other co-existing factor alongside with pes planus, which are Achilles tendon contracture (ATC) and posterior tibial tendon dysfunction (PTTD) were reported to have a negative impact on the ankle instability as well. Therefore, the aim of this study is to investigate the correlation between ATC and PTTD with ankle instability among young adults with pes planus.

Methods: A correlational study was conducted to investigate the correlation between ATC and PTTD with ankle instability among young adults with pes planus. Young adults from UTAR Sungai Long campus were recruited and screened for the presence of pes planus with Chippaux-Smirek Index (CSI) after obtaining their footprints. Recruited participants were screened for the presence of ATC with Silfverskiold test, presence of PTTD with single heel raise test (SHRT) and presence of ankle instability with Y balance test.

Results: Data from 57 out of 177 participants were analyzed. Among the 57 young adults, 31 were male and 26 were female. Pearson Chi-Square and Fisher's Exact Test revealed that there was no significant relationship between ATC alone with ankle instability, PTTD alone with ankle instability, and both ATC and PTTD with ankle instability among young adults with pes planus.

Conclusions: This study concluded that there is no significant relationship between ATC alone with ankle instability, PTTD alone with ankle instability, and both ATC and PTTD with ankle instability among young adults with pes planus.

Keywords: pes planus, Achilles tendon contracture, posterior tibial tendon dysfunction, ankle instability, young adults

ACKNOWLEDGEMENT

Upon completion of this research project, I hereby would like to express my most sincere gratitude and appreciation to those who had provided their assistance and guidance for me throughout the preparation and completion of this research project.

First and foremost, I wish to express my deepest gratitude to Dr. Deepak Thazhakkattu Vasu, my supervisor for his guidance, patience and encouragement throughout the development of this study. He had provided many opinions and suggestions since the start of topic selection to the end of this study, even with the precise details that I had omitted.

Apart from that, I would like to provide my greatest appreciations to all the participants for their precious time from their busy schedule to participate in this study.

I am also grateful to Tan Bee Thong, Ong Chuu Chyi, Low Xin Yuen, Gienisha a/p Thanapalan and all of my fellow friends and classmates for providing tremendous help during the participant recruitment and data collection period of my study. Without them, I would not be able to complete the collection of data for the large number of participants successfully within a short period of time.

Lastly, I wish to thank my parents and family members for their support mentally and physically throughout the implementation of this project. With their support, it brings me to where I am now. Even though the journey had been a tough one, but winter never fails to turn to spring, the obstacles had not demotivated me to strive harder to continue the path.

APPROVAL SHEET

This Research project entitled "**A CORRELATION STUDY BETWEEN ACHILLES TENDON CONTRACTURE AND POSTERIOR TIBIAL TENDON DYSFUNCTION ON ANKLE INSTABILITY AMONG YOUNG ADULTS WITH PES PLANUS**" was prepared by SEE WAN NI and submitted as partial fulfillment of the requirements for the degree of Bachelor of Physiotherapy (Honours) at Universiti Tunku Abdul Rahman.

Approved by:

____

(Dr. Deepak Thazhakkattu Vasu) Date:............................
Supervisor
Department of Physiotherapy
M. Kandiah Faculty of Medicine and Health Sciences
Universiti Tunku Abdul Rahman

Approved by:

____

(Mr. Muhammad Noh Zulfikri bin Mohd Jamali) Date:............................
Head of Department
Department of Physiotherapy
M. Kandiah Faculty of Medicine and Health Sciences
Universiti Tunku Abdul Rahman

M. KANDIAH FACULTY OF

MEDICINE AND HEALTH SCIENCES

UNIVERSITI TUNKU ABDUL RAHMAN

Date:

PERMISSION SHEET

It is hereby certified that **SEE WAN NI** (ID No: **19UMB03675**) has completed this Research project entitled "A CORRELATION STUDY BETWEEN ACHILLES TENDON CONTRACTURE AND POSTERIOR TIBIAL TENDON DYSFUNCTION ON ANKLE INSTABILITY AMONG YOUNG ADULTS WITH PES PLANUS" under the supervision of Dr. Deepak Thazhakkattu Vasu (Supervisor) from the Department of Physiotherapy, M. Kandiah Faculty of Medicine and Health Sciences.

Yours truly,

____

(SEE WAN NI)

DECLARATION

I hereby declare that the Research project is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UTAR or other institutions.

Name: SEE WAN NI

Date:

TABLE OF CONTENTS

	Page
ABSTRACT	**ii**
ACKNOWLEDGEMENT	**iii**
APPROVAL SHEET	**v**
PERMISSION SHEET	**vi**
DECLARATION	**vii**
TABLE OF CONTENTS	**viii**
LIST OF TABLES	**xii**
LIST OF FIGURES	**xv**
LIST OF ABBREVIATION	**xvii**
CHAPTERS	
I. INTRODUCTION	**1**
1.1 Background of Study	1
1.2 Objective of Study	6
1.2.1 General Objective	6
1.2.2 Specific Objectives	6
1.3 Research Question	7
1.4 Hypothesis	7
1.4.1 Null Hypothesis, H_0	7
1.4.2 Alternate Hypothesis, H_1	7
1.5 Operational Definition	8
1.6 Rationale of Study	8
1.7 Scope of Study	10
II. LITERATURE REVIEW	**12**
2.1 Prevalence of Pes Planus	12
2.2 Pathomechanics of Pes Planus	15
2.3 Complications of Pes Planus	18
2.4 Relationship between Ankle Instability and Pes Planus	21
2.4.1 Associating Factors – Achilles Tendon Contracture (ATC)	23

2.4.2 Associating Factors – Posterior Tibial Tendon Dysfunction (PTTD) 25
2.5 Assessment Method 27
2.5.1 Pes Planus 27
2.5.2 Ankle Instability 29
2.5.3 ATC 30
2.5.4 PTTD 31
2.6 Management for Pes Planus 31
2.7 Conclusion 33

III. MATERIALS AND METHODS **35**
3.1 Chapter Overview 35
3.2 Study Design 35
3.3 Study Setting 36
3.4 Study Populations 36
3.5 Sample Size 36
3.6 Sampling Method 37
3.7 Inclusion Criteria 37
3.8 Exclusion Criteria 38
3.9 Instrumentation 38
3.9.1 Stadiometer 38
3.9.2 Footprint ink and paper 39
3.9.3 Basin 40
3.9.4 Measuring tape 40
3.9.5 Goniometer 41
3.9.6 Plinth 42
3.9.7 Y Balance Test Kit 43
3.10 Procedure 43
3.11 Statistical Analysis 54
3.12 Ethical Approval 54

IV. RESULTS **55**
4.1 Chapter Overview 55
4.2 Demographic Data of the Participants 55
4.2.1 Age Distribution of Participants 57

4.2.2 Gender Distribution of Participants 58
4.2.3 BMI Category Distribution of Participants 59
4.2.4 Activity Level of Participants 60
4.2.5 Sports Involvement by the Participants 61
4.2.6 Frequency of Sport(s) Participations by the Participants 62
4.3 Outcome Measures among All Participants 63
4.3.1 Degree of Severity among Participants 64
4.3.2 Leg Dominance among Participants 65
4.3.3 Nature of Pes Planus among Participants 66
4.3.4 Presence of ATC or PTTD among Participants 67
4.3.5 Presence of Ankle Instability among Participants 68
4.4 Gender, Leg Dominance, Achilles Tendon Contracture, PTTD and Ankle Instability Distribution Among Participants based on Degree of Severity 69
4.5 Gender, Leg Dominance, Achilles Tendon Contracture, PTTD and Ankle Instability Distribution Among Participants based on Nature of Pes Planus 72
4.5.1 Pes Planus Distribution within Genders 73
4.5.2 Pes Planus Distribution on Dominant Side of Participants 74
4.5.3 Presence of ATC or PTTD among Pes Planus Participants 75
4.5.4 Ankle Instability among Pes Planus Participants 76
4.6 Correlation between ATC and PTTD with Ankle Instability among all Pes Planus Participants 77
4.7 Correlation between ATC and PTTD with Ankle Instability among Unilateral Pes Planus Participants 80
4.8 Correlation between ATC and PTTD with Ankle Instability among Bilateral Pes Planus Participants 83
4.9 Correlation between ATC and PTTD with Ankle Instability among Pes Planus on Dominant Leg of Participants 86
4.10 Correlation between ATC and PTTD with Ankle Instability among Participants with 3rd Degree of Severity of Pes Planus 89
4.11 Correlation between ATC and PTTD with Ankle Instability among Participants with 2nd Degree of Severity of Pes Planus 95
4.12 Correlation between ATC and PTTD with Ankle Instability among Participants with 1st Degree of Severity of Pes Planus 101

V. DISCUSSION 107
5.1 Chapter Overview 107
5.2 Demographic Findings 107

5.2.1 BMI Category Distribution 108
5.2.2 Physical Activity Distribution 109
5.2.3 Nature of Pes Planus Distribution 110
5.2.4 Leg Dominance Distribution 110
5.2.5 Degree of Severity Distribution 111
5.2.6 Prevalence of ATC and PTTD among Young Adults 112
5.2.7 Prevalence of Ankle Instability among Young Adults 114
5.3 Correlation between ATC Alone with Ankle Instability 115
5.4 Correlation between PTTD Alone with Ankle Instability 116
5.5 Correlation between Both ATC and PTTD with Ankle Instability 118
5.6 Limitations of Study 121
5.7 Recommendations for Future Study 122

VI. CONCLUSION 124
REFERENCE 126
APPENDICES 136
APPENDIX A: ETHICAL APPROVAL LETTER 136
APPENDIX B: APPLICATION FOR VENUE BOOKING 139
APPENDIX C: APPLICATION FOR EQUIPMENT BOOKING 140
APPENDIX D: PERSONAL DATA PROTECTION STATEMENT 141
APPENDIX E: INFORMATION SHEET AND CONSENT FORM 143
APPENDIX F: DEMOGRAPHIC DATA COLLECTION FORM 146
APPENDIX G: ASSESSMENT FORM 151
APPENDIX H: TURNITIN REPORT 152

LIST OF TABLES

Table		Page
4.1	Demographic Data of the Participants	56
4.2	Outcome Measures among All Participants	63
4.3	Distribution Among Participants Based on Degree of Severity	69
4.4	Distribution Among Participants Based on Nature of Pes Planus	72
4.5	Correlation between ATC and Ankle Instability among all Pes Planus Participants	77
4.6	Correlation between PTTD and Ankle Instability among all Pes Planus Participants	78
4.7	Correlation between Both ATC and PTTD with Ankle Instability among all Pes Planus Participants	79
4.8	Correlation between ATC and Ankle Instability among Unilateral Pes Planus Participants	80
4.9	Correlation between PTTD and Ankle Instability among Unilateral Pes Planus Participants	81
4.10	Correlation between Both ATC and PTTD with Ankle Instability among Unilateral Pes Planus Participants	82
4.11	Correlation between ATC and Ankle Instability among Bilateral Pes Planus Participants	83
4.12	Correlation between PTTD and Ankle Instability among Bilateral Pes Planus Participants	84
4.13	Correlation between Both ATC and PTTD with Ankle Instability among Bilateral Pes Planus Participants	85
4.14	Correlation between ATC and Ankle Instability among Pes Planus on Dominant Leg of Participants	86
4.15	Correlation between PTTD and Ankle Instability among Pes Planus on Dominant Leg of Participants	87
4.16	Correlation between Both ATC and PTTD with Ankle Instability among Pes Planus on Dominant Leg of Participants	88
4.17	Correlation between ATC and Ankle Instability among Participants with 3rd Degree of Severity of Pes Planus on Right Foot	89

4.18 Correlation between ATC and Ankle Instability among Participants with 3rd Degree of Severity of Pes Planus on Left Foot 90

4.19 Correlation between PTTD and Ankle Instability among Participants with 3rd Degree of Severity of Pes Planus on Right Foot 91

4.20 Correlation between PTTD and Ankle Instability among Participants with 3rd Degree of Severity of Pes Planus on Left Foot 92

4.21 Correlation between Both ATC and PTTD with Ankle Instability among Participants with 3rd Degree of Severity of Pes Planus on Right Foot 93

4.22 Correlation between Both ATC and PTTD with Ankle Instability among Participants with 3rd Degree of Severity of Pes Planus on Left Foot 94

4.23 Correlation between ATC and Ankle Instability among Participants with 2nd Degree of Severity of Pes Planus on Right Foot 95

4.24 Correlation between ATC and Ankle Instability among Participants with 2nd Degree of Severity of Pes Planus on Left Foot 96

4.25 Correlation between PTTD alone and Ankle Instability among Participants with 2nd Degree of Severity of Pes Planus on Right Foot 97

4.26 Correlation between PTTD and Ankle Instability among Participants with 2nd Degree of Severity of Pes Planus on Left Foot 98

4.27 Correlation between Both ATC and PTTD with Ankle Instability among Participants with 3rd Degree of Severity of Pes Planus on Right Foot 99

4.28 Correlation between Both ATC and PTTD with Ankle Instability among Participants with 3rd Degree of Severity of Pes Planus on Left Foot 100

4.29 Correlation between ATC and Ankle Instability among Participants with 1st Degree of Severity of Pes Planus on Right Foot 101

4.30 Correlation between Achilles Tendon Contracture and Ankle Instability among Participants with 1st Degree of Severity of Pes Planus on Left Foot 102

4.31 Correlation between PTTD and Ankle Instability among Participants with 1st Degree of Severity of Pes Planus on Right Foot 103

4.32	Correlation between PTTD and Ankle Instability among Participants with 1st Degree of Severity of Pes Planus on Left Foot	104
4.33	Correlation between Both ATC and PTTD with Ankle Instability among Participants with 1st Degree of Severity of Pes Planus on Right Foot	105
4.34	Correlation between Both ATC and PTTD with Ankle Instability among Participants with 1st Degree of Severity of Pes Planus on Left Foot	106

LIST OF FIGURES

Figure		Page
3.1	SECA Stadiometer (Mod 220)	39
3.2	A3 Paper	39
3.3	Poster Colors for the Footprint Ink	40
3.4	The Basin on the Left contains Clean Water while the Basin on the Right contains the Footprint Ink	40
3.5	Measuring Tape	41
3.6	Goniometer	42
3.7	Plinth	42
3.8	Y Balance Test Kit	43
3.9	Poster used for Participant Recruitment	44
3.10	Weight and Height Measurement Taking	45
3.11	Participant stepped on the Basin filled with Ink	46
3.12	Participant printing their Footprint in Weightbearing Position	46
3.13	Example of Footprint Printed Out from the Participants	47
3.14	Measurement for CSI value	47
3.15	Position of goniometer during Knee Extension	48
3.16	Position of goniometer during Knee Flexion	48
3.17	Participant with Their Heel Raised on Single Leg during the SHRT	49
3.18	Participant performing Y balance test in Anterior Direction of Right Leg	51
3.19	Participant performing Y balance test in Posteromedial Direction of Right Leg	52
3.20	Participant performing Y balance test in Posterolateral Direction of Right Leg	52
3.21	Procedure of Pelvic Squaring before obtaining the measurement of limb length	53
3.22	Procedure of Limb Length Measurement on the Left Limb with ASIS and Medial Malleolus as Reference Point	53
4.1	Distribution of Age of Participants	57
4.2	Distribution of Gender of Participants	58
4.3	Distribution of BMI Category of Participants	59

4.4	Distribution of Activity Level of Participants	60
4.5	Distribution of Sports Involvement by the Participants	61
4.6	Frequency of Sport(s) Participations Distribution of the Participants	62
4.7	Distribution of Pes Planus Degree of Severity on the Right and Left Foot	64
4.8	Distribution of Leg Dominance among Participants	65
4.9	Distribution of Nature of Pes Planus among Participants	66
4.10	Distribution of Presence of ATC or PTTD among Participants	67
4.11	Distribution of Presence of Ankle Instability among Participants	68
4.12	Distribution of Genders among Participants with Pes Planus	73
4.13	Distribution of Pes Planus on Dominant Side of Participants	74
4.14	Distribution of Presence of ATC or PTTD among Participants with Pes Planus	75
4.15	Distribution of Ankle Instability among Participants with Pes Planus	76

LIST OF ABBREVIATION

ATC	Achilles Tendon Contracture
BESS	Balance Error Scoring System
BMI	Body Mass Index
CA	Clarke's Angle
CIa	Calcaneal Inclination angle
CSI	Chippaux-Smirak Index
ICC	Intraclass Correlation Coefficient
MEa	Meary's angle
p	*p* value (Significance)
PTTD	Posterior Tibial Tendon Dysfunction
QOL	Quality of life
RR	Risk Ratio
SEBT	Star Excursion Balance Test
SHRT	Single Heel Raise Test
USBT	Unipedal Standing Balance Test
UTAR	Universiti Tunku Abdul Rahman

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Stability is a complex motor task which involves the integration of sensory information on body postures and appropriate motor response of the musculoskeletal system for postural control in respect to the influence of internal and external environment factors (Karakaya et al., 2015). It is inevitable that stability plays a major role in maintaining the centre of gravity of an individual within the base of support. However, this is unable to be achieved without a good stability of the ankle joint. As the first major joint that absorbs shock during the first contact of foot to the ground, this complex joint made stability possible through the anatomical advantage with stabilizing elements. Despite of this advantages, continuous ankle injuries occurring over the ankle will leads to disruption of the ankle stability, resulting in ankle instability.

Ankle instability is usually characterized as sensation of “giving way”, where individuals often experience recurrent sprains in the ankle and is primarily affected by the instability of the lateral component of the ankle joint, lateral ligamentous instability (Santos & Liu, 2008). Through statistics, it is found that 32% to 74% of the individuals who had history of ankle injuries tends to suffer from ankle instability (Gribble et al., 2013). Followed by failure of ankle injuries management, these individuals are trapped in an endless cycle, whereby they are more prone to ankle injury due to the development of ankle instability. The increasing falling risk in respect to the ankle instability is negatively associated to the increasing occurrence of ankle injuries, where these individuals tend to develop habitual ankle sprains more easily than the others. Several studies had found that there is an association between the stability of the ankle with the arches of the foot, especially individuals with pes planus. Stability among these individuals were compromised with significant decrease found in both static stability and dynamic stability, and even worst with the exclusion of visual input (Tahmasebi et al., 2015; Sung et al., 2017; Koshino et al., 2020; Adegoke et al., 2021; Marouvo et al., 2021). Furthermore, this has increased the risk of injury among these individuals where they are found to encounter ankle sprains and recurrent ankle sprains more frequently than the individuals with other types of foot arch (Mei-Dan et al., 2005).

Pes planus, more commonly referred as flat foot, is a condition which is characterized by the decreased or absence in the height of the medial longitudinal arch of the foot and is usually occurred alongside with excessive pronation of the foot (Tahmasebi et al., 2015; Sharma & Upadhyaya, 2016). It is evaluated that 20% to 37% of the populations worldwide are found with this foot deformity (Raj et al., 2022). By further investigating into the young adult populations, the prevalence shows a percentage of 11.25% to 20% (Bhoir et al., 2014; Khadanga & Kumar, 2022). As a result of the collapse of medial longitudinal arch of the foot, the healthy biomechanics of the foot structure are altered in response to the compensatory mechanism of the body to neutralize the deformity. In such, study conducted by Sung et al. (2017) found that there is significant difference on the threshold level (F=369.23, p=0.001) and group interactions with threshold (F=6.72, p=0.01) between individual with normal feet and individual with pes planus during leg standing with contralateral hip and knee in flexed position. In addition, Sharma & Upadhyaya (2016) found that pes planus is significantly influencing on the running performance of these individuals, especially on short explosive events such as sprinting where huge amount of stress is placed on the foot musculature.

Not only the presence of this defect in foot arch had influenced the stability of the ankle and normal biomechanics, but also the physical activity and fitness level of the individual. Truszczyńska-Baszak et al. (2017) had observed that there is a greater number of participants with the lowered foot arches and pes planus falls in the group of minimum or moderate physical activity level. Young adults of the age 18 to 25 years old often are engaged in physical activities and sport events where stability plays a major role for fall prevention. This physically activities avoidance may be greatly associated with ankle instability that persist within these individuals, resulting phobia to develop as self-protecting mechanism. They will inhibit themselves to involve in any activities that will lead to reoccurrence of ankle sprains unintentionally. This phenomenon is observed in study conducted by Furgał & Adamczyk (2008) where the individuals showing greater prevalence of pes planus were the children whom restricted themselves from outdoor activities during their physical exercise classes. The reduction of physical activity level will further lead to the increase of body mass index (BMI), which cause further deterioration on the foot arch.

Although based on the literature review, pes planus is the major factor that affecting on the stability of the ankle. However, it is found that other associating factors may increases the risk of ankle instability to develop especially among these individuals as well. Factors that co-exist with pes planus such as Achilles tendon contracture (ATC) and posterior tibial tendon dysfunction (PTTD) are found to result in an increasing risk of ankle pain and ankle injury (Cheung et al., 2006; Endo & Sakamoto, 2014; Bubra et al., 2015; Wang et al., 2022). The prolong adaptation by our body in response to compensate this alteration will consequently causes the development of ankle instability.

ATC is the shortening of the Achilles tendon, resulting in the reduction in range of motion of the ankle joint and subtalar joint. As mentioned by Hill (1995), 96.5% of the patients with presence of Achilles tendon contracture had shown restricted dorsiflexion over the ankle, causing compensation to occur during gait where injury over the ankle may occur as these individuals failed to stabilize themselves due to the restricted range of motion over the ankle. This poor stabilization is observed in study conducted by Endo & Sakamoto (2014), where these individuals exhibit significant reduction in reach distance during the execution of Star Excursion Balance test (SEBT). Furthermore, this contracture is found to be one of the risk factors associated to the development of pes planus where this shortening is present in all the teenagers with pes planus in the experimental group with a prevalence of 77% (Reimers et al., 1995).

Posterior tibial tendon, as a foot invertor, it is vital in maintaining the medial longitudinal arch of the foot and stabilizing the hindfoot preventing the development of valgus deformity (Lin et al., 2015). Dysfunction in this tendon will be referred as PTTD, or sometimes also referred as posterior tibial tendon insufficiency. Since the maintainer of the medial longitudinal arch is disrupted, this dysfunction will be further progressed and leads to the development of pes planus. The development of PTTD may influences the functional capacity and stability of an individual. According to research conducted by Kulig et al. (2015), it is observed that women with PTTD performed lesser maximal height during single-leg heel raises and difficulty in performing unipedal standing balance test (USBT) where most of them either failed to attain in the posture or with greater grade of postural sway. To add on, the swing phase of these affected individuals tend to exhibit more prominent medially shifted pattern for the center of pressure compare to the others (Wang et al., 2022). This fluctuation of the stability within the individuals with PTTD may be greatly associated to ankle instability that develops as a result of the defect in the foot arch.

Although these underlying factors may be thought as driving key factors which contributing to the greater risk of ankle instability to occurred in individuals with pes planus, considerations in managing these underlying factors in pes planus treatment should be taken in action as well. However, the correlation between these factors in relation to ankle instability in individual with pes planus is poorly studied and no studies had been conducted to test and discussed that these factors may be a major issue to the higher prevalence of ankle instability among young adults with pes planus than young adults with healthy feet. Hence, this study is conducted to prove that ATC and PTTD are correlated to increasing risk of ankle instability to developed among young adults with pes planus, as well as to compare in between the correlation of these two underlying conditions in which will poses greater risk for the development of ankle instability to occur among young adults with pes planus.

1.2 Objective of Study

1.2.1 General Objective

The general objective of this study was to determine the correlation of ATC and PTTD with ankle instability in young adults with pes planus.

1.2.2 Specific Objectives

The specific objectives of this study were as follow:

1. To determine the correlation of ATC with ankle instability in young adults with pes planus.
2. To determine the correlation of PTTD with ankle instability in young adults with pes planus.
3. To compare the correlation of ATC and PTTD with ankle instability in young adults with pes planus.

1.3 Research Question

The research questions of this study were as follow:

1. Is there significant relationship between ATC and ankle instability in young adults with pes planus?
2. Is there significant relationship between PTTD and ankle instability in young adults with pes planus?
3. Is there significant relationship between both ATC and PTTD with ankle instability?

1.4 Hypothesis

1.4.1 Null Hypothesis, H_0

1. There is no correlation between ATC with ankle instability in young adults with pes planus.
2. There is no correlation between PTTD with ankle instability in young adults with pes planus.
3. There is no correlation between both ATC and PTTD with ankle instability in young adults with pes planus.

1.4.2 Alternate Hypothesis, H_1

1. There is correlation of ATC with ankle instability in young adults with pes planus.
2. There is correlation of PTTD with ankle instability in young adults with pes planus.

3. There is correlation between both ATC and PTTD with ankle instability in young adults with pes planus.

1.5 Operational Definition

1. Pes planus: A type of foot deformity where the curvature of medial longitudinal arch of the foot appears more flat than normal foot, causing the sole of the foot came into partial or complete contact with the supporting surface (Lovett & Dane, 1896)

2. Ankle Instability: A condition in which individuals will experience recurrent sprains or sensation of "giving way" at the ankle during movement (Santos & Liu, 2008).

3. Achilles tendon contracture (ATC): An orthopaedic condition involving the functional tightness of which occur on the gastrocnemius-soleus complex.

4. Posterior tibial tendon dysfunction (PTTD): An orthopaedic condition which occur due to inflammation or rupture of posterior tibial tendon.

1.6 Rationale of Study

As one of the most common foot deformities in the population, pes planus had been affecting the population from several aspect. Where it had been restricting these group of individuals from physical activity participations due to fear of ankle injuries with respect to the development of ankle instability (Furgał & Adamczyk, 2008; Truszczyńska-Baszak et al., 2017). This phenomenon is sad to be seen among individuals within the age group of 18 to 25 years old as this period of time is the most productive years in their life. Withdrawal from physical activities not only will reduces the opportunity for these individuals to socialize around, but also negatively impacting on their health. This is because physical activity is vital in health maintenance, either physically or mentally. Apart from pes planus, the higher prevalence of ATC and PTTD are found associated to the increasing risk of ankle instability. In which, ATC and PTTD with prevalence of 77% and 13.51% respectively had been found to have a positive correlation with ankle instability (Reimers et al., 1995; Kohls-Gatzoulis et al., 2009).

Based on these findings, pes planus is important to be manage among young adults to prevent physical activity restriction as a result of the continuous progression of ankle instability. Unfortunately, no data was found in regards to the correlation of ankle instability among young adults with the presence of ATC or PTTD, neither on young adults who are having pes planus. Not to mention on the comparison between these two variables in which will create a greater impact to the functional stability of young adults with pes planus. Hence, it is important for this study to be conducted in order to determine the correlation between the coexisting conditions along with pes planus, which are ATC and PTTD with ankle instability among young adults who are having pes planus, as well as to further compare in between the two coexisting orthopaedic condition to determine which factors will poses greater risk of ankle instability to develop among pes planus individual, especially among young adults. By knowing this knowledge gap, effective management and treatment only can be formulate in order to prevent and manage this drastic effect which will further harming and increased the risk of injury to occur among these individuals based on the data obtained. Therefore, this research aim to address this knowledge gap by focusing on determining and comparing the correlation of ATC and PTTD on ankle instability among young adults with pes planus. Thus, providing better understanding on how ankle instability is influenced by coexisting factors of pes planus, the Achilles tendon contracture and PTTD, and which factors is posing higher risk of ankle instability to develop among young adults with pes planus.

1.7 Scope of Study

Through reviewing published articles and literature, there is lack of research and understanding regarding the other associating factors in addition to pes planus that are causing the occurrence of ankle instability among young adults with pes planus, as well as comparison between which conditions will poses greater risk to the young adults for the development of pes planus. Hence, this study is to address this knowledge gap by proving that ATC and PTTD are correlated to ankle instability among young adults with pes planus. With the result obtained from this study, we will be able to revise and improve the current treatment protocol for patients with pes planus. As a consequence, it helps to encourage and regain confidence for physical activity participation which had been restricted within these individuals due to fear of recurrent ankle injuries as a result of ankle instability. This is achievable as the result obtain will provide physiotherapists with better ideas on the correlation of other associating factors that are contributing to the cause of ankle instability among pes planus young adults. Thus, physiotherapists can include treatments to address ATC and PTTD when treating ankle instability patients with pes planus, hence reducing the rehabilitation period for the patient and preventing instability among these patients to progress further that may cause devastating effect on these individual’s physical activity participations.

CHAPTER 2

LITERATURE REVIEW

2.1 Prevalence of Pes Planus

Pes planus is one of the most common foot deformities that are observed across the populations despite age, gender and race. Pes planus can be either congenital or acquired. Congenital pes planus or flexible pes planus are often seen among children as it develops secondarily to ligamentous laxity and insufficient neuromuscular control. While acquired pes planus primary in adults occurred as complication secondary to PTTD, obesity, previous history of trauma or fracture to the foot, ligamentous laxity or arthropathy (Raj et al., 2022).

Several studies have been conducted over worldwide to investigate the prevalence of pes planus in the population. Through these studies, we found that pes planus affects partial of the populations ranging from children to adults. In which, it is found that children to adolescents within the age range of 3 to 15 years old have a greater prevalence of pes planus, with the result of 5% in Nigeria, 20.1% in Southern India, 25% in Poland, 29.5% in Saudi Arabia, 44% in Austria and 57.5% in Eastern India (Alakija, 1979; Pfeiffer et al., 2006; Klimczak et al., 2014; Bhattacharjee & Goswami, 2017; Senthil Prabhu et al., 2018; Alsuhaymi et al., 2019). On the other hand, the prevalence of pes planus in adults that are aged 18 years old and above was found to have a prevalence of 11.6% in

Nigeria,13.6% in Western India, 26.62% in Spain, 53% in females in Malaysia (Aenumulapalli et al., 2017; Pita-Fernandez et al., 2017; Shariff et al., 2017; Okezue et al., 2019). However, particular among young adults who aged between 18 to 25 years old, studies have found that this group of populations exhibits a prevalence of 11.25% to 20% with the presence of pes planus (Bhoir et al., 2014; Khadanga & Kumar, 2022). Moreover, pes planus occurs more frequently in bilateral manner rather than unilaterally. This is shown with a prevalence found with 11.6% of bilateral pes planus individuals, while unilateral pes planus with a prevalence of only 3% among young adults (Reddy & Kishve, 2021).

In speaking of gender wise, no significant difference was found between girls and boys in the age range of 7 to 12 where a percentage of pes planus is observed as 75.2% for girls and 72.6% for boys (Kachoosangy et al., 2013). However, this trend seems to differ as the target population changes from youngsters to young adults. Studies found that males tend to portraying greater prevalence of the presence of pes planus compared to females with a percentage of 6.3% for the right foot and 4.2% for the left foot, while females have lower prevalence of 3.6% for the right foot and 3.1% for the left foot (Igbinedion et al., 2022). This finding is also supported by result obtained by Khadanga & Kumar (2022), where males shows a prevalence of 21.55% while females only shows a prevalence of 17.97%.

Furthermore, researchers found that there is a positive correlation between BMI with the presence of pes planus. Although not all individuals in the obese and overweight category present with this deformity of the foot arch, however, this group of people tends to have significantly higher prevalence when compare with individuals who arises from other BMI categories. This theory is supported through studies where the overweight and obese children had a significantly high percentage of 26.9% and 30.8% compared to underweight and normal-weight children with a percentage of 13.9% and 16.1% (Pourghasem et al., 2016). Through the review, the prevalence of pes planus seems to obtain a wide range of 14% to 67% among obese children, suggesting that obese or an increase in weight will tend to increase the prevalence of pes planus among these populations (Stolzman et al., 2015). On the other hand, a study conducted by Shariff et al. (2017) investigating female adults in Malaysia, the fattest country in Asia with obesity adults prevalence as high as 18.6% in 2021, found that this group of the population had showed statistics of 18% and 51% for an obese and overweight female to develop this deformity of the foot arch (Mohd-Sidik et al., 2021).

The higher prevalence shown among individuals with greater BMI index are partly due to greater prevalence of withdrawal from physical activity. Physical activity is vital in regulating our health. Thus, reduction of participations will cause the increases of weight, resulting on the increase of BMI index. It is found that 62.5% and 39.5% of the girls and boys, whom were found with defect in the foot arch, are those who refuse to participate in any of the outdoor activities during their PE lessons (Furgał & Adamczyk, 2008). This finding is supported by Truszczyńska-Baszak et al. (2017), where they found that the lowering of medial longitudinal arch will cause reduction in the participation of physical activity and fitness level of the individuals. To further explained, the individuals in this study who were found with greater prevalence of pes planus or lowered arch are those who are physically inactive. However, the individuals who were physically active were found free from pes planus and demonstrated a normal foot arch.

To summarize, factors such as gender, BMI index and physical activity are contributable to the increasing risk of the development of pes planus. As males, overweight and obese category and low physical activity level are found with higher prevalence of pes planus compare to females, normal BMI category and high physical activity level.

2.2 Pathomechanics of Pes Planus

The foot complex is structurally made up of 28 bones, forming 25 component joints. These joints include proximal and distal tibiofibular joints, ankle (talocrural) joint, subtalar (talocalcaneal) joint, transverse tarsal (talonavicular and calcaneocuboid) joints, five tarsometatarsal joints, metatarsophalangeal joints and nine interphalangeal joints. These components permit the foot complex in both stability and mobility depending on the factors acting on it (Levangie et al., n.d.). According to Reeser et al. (1983), the maintenance of the arch of the foot during static is supported by passive ligamentous and osseous support (Donatelli, 1985), in which the ligaments are spring (calcaneonavicular) ligament, short plantar ligaments and long plantar ligaments. On the other hand, bones act as the major stabilizers of the foot (Donatelli, 1985). However, during dynamic movements, the arrangement of the foot complex that resembles a closed kinetic chain caused motion at one joint will affects and influences the mechanisms of other joints within the chain, moving as a unit (Donatelli, 1985). Hence, the biomechanics of the foot is important to be preserved. This is because the foot plays a vital role in sustaining weight-bearing stress while performing various activities, providing adequate base of support and act as a rigid lever during push-off phase of walking, running or jumping, and act as shock absorber as the foot strikes the ground (Levangie et al., n.d.).

Attributable to the abnormal falling in the medial longitudinal arch, the normal biomechanics of the foot is disrupted. From the context of Kodithuwakku Arachchige et al. (2019), individuals with pes planus have feet that are structurally differ from the normal individual on the rear-foot varus, which eventually will lead to the excessive pronation of the foot develops during weight bearing position. Besides, distinctive features such as deepened navicular cup, widened talus articular surface, talus which faced proximally and shifts of navicular articular surface to a higher position are prominent alterations that can be observed through the naked eye. These alterations are contributing cause to the collapsing of the medial longitudinal arch of the foot, resulting in the absence of foot arch in these individuals that are identified as either rigid flatfeet, where the loss of foot arch is seen during both non-weight bearing position and weight bearing position; or flexible flatfeet, where the loss of foot arch is only seen during weight bearing position and the normal arch is observed during non-weight position. In addition, a study conducted by Ledoux et al. (n.d.) had discovered that individuals with pes planus were found to have a significant increase of lateral talometatarsal angle and length of the second metatarsal.

The abovementioned biomechanical alteration will hamper the foot health. Where Towers et al. (2003) mentioned that this alteration will lead to increase the flexibility of the foot compared to the normal foot, allowing more significant load to be absorbed. Pes planus individual had shown a noticeable increase of hindfoot eversion, peak forefoot plantarflexion, forefoot abduction, internal rotation of tibial, rearfoot eversion excursion, rearfoot eversion velocity, subtalar joint eversion; while showing a reduction in peak forefoot adduction and forefoot abduction during toe-off phase (Levinger et al., 2010; Kodithuwakku Arachchige et al., 2019). In addition, it is reported that this altered alignment of the foot will influence the muscle strength of the intrinsic foot muscles, which are abductor hallucis, flexor hallucis brevis, flexor digitorum brevis, and interosseous muscles (Jung et al., 2011). Whereas it is also found that the foot pressure is more concentrated at the second and third metatarsal areas when compared to the normal foot during dynamic activities. This altered plantar pressure distribution is more prominent to be seen during quiet standing, creating an impact on the stability of these individuals which subsequently exposing these individual to greater risk of lower limb injuries (Periyasamy & Anand, 2013; Kim, 2015).

Hence, the development of pes planus not only causes a defect on the medial longitudinal arch, but on the rearfoot angle as well. This causes the foot to appear excessively pronated. However, this deformity had an impact on the overall foot health as well, especially the intrinsic foot muscles. Due to the collapse of foot arch, the distribution of weight is significantly influenced, which is not in the biomechanical advantage.

2.3 Complications of Pes Planus

Although pes planus may seem to be just the malalignment of the medial longitudinal arch of the foot. However, as mentioned above, a small defect in the ankle foot will causes drastic effect which influences the other parts of the joint as well, where 68.3% of the affected individuals are experiencing functional limitation (Benedetti et al., 2011). Thus, sequelae of the pes planus will cause negative impact on an individual's quality of life (QOL), functional disability and mental health. According to study conducted by Gonzalez-Martin et al. (2018), participants are found to have significant reduction in QOL and functionality through Foot Health Status Questionnaire (FHSQ) and Foot Function Index (FFI) questionnaires. Furthermore, Dabholkar & Agarwal (2020) found that pes planus individuals have a total disability percentage ranged between 21% to 65%, in 34% is classified as pain and stiffness, 37% is classified as activity limitation and 37% is classified as social domains. In which, activity limitation was further proven by Furgał & Adamczyk (2008) where these group of individuals tend to restrict themselves in participating any of the physical activities. On the other hand, it is also studied that pes planus will compromise the stability of an individual, leading to mild, moderate and severe ankle injuries.

Ankle injuries are one of the injuries that occurs most frequently among the populations, despite being physically active or inactive. Based on Cooke (2003), ankle sprain made up 3% to 5% of the incidences in Emergency Department in United Kingdom, equivalent to 5600 incidences daily. According to (Hølmer et al., 1994), there was approximately 36000 ankle injuries happened annually in Denmark, where 45% occurred during sports activity, 20% during play and 16% during work. Among athletes, ankle is found to be the body part which sustained injury most frequently, with a percentage of 34.3% out of 70 sports where 76.7% are compromised by ankle sprain and 16.3% as ankle fracture (Fong et al., 2007). Thus, we can conclude that ankle injury is common to occur, nevertheless among the pes planus individuals whom came with biomechanically disadvantages. The instability in these individuals as a result of the altered alignment in foot has exposing these individuals to develop ankle injuries more easily. In which, it is reported that out of 99 ankle injuries, 14.1% of these patients suffered from pes planus as well (Michelson et al., 2002). According to Mei-Dan et al. (2005), they found that soldiers with pes planus poses greater frequency of ankle sprains and recurrent ankle sprains with risk ratio (RR) of 2.9, $p < 0.05$ and RR of 10.3, $p < 0.05$ respectively, compared to soldiers with normal feet or pes cavus.

The loss of medial longitudinal arch does not only affect the ankle joint of the affected individual, but also affecting the knee joint as well. With the presence of this defect, individuals tend to compensate this defect with excessive pronation. Thus, leading to the appearance of genu valgum, or more commonly known as “X leg”. With reference to N. AlKhouli et al. (2017), researchers found out that significant increase of the Q-angle is observed from individuals with pes planus when compared to normal individuals. This significant increase of the Q-angle found among the participants is problematic, as these individuals tends to suffer from knee injuries more easily than the others. In which, studies found that the increasing Q-angle had subsequently increases the risk of patella subluxation as well, which will further lead to the development of knee pain slowly among the affected individuals. This is proven by study conducted by Han et al. (2017), where the presence of heel valgus that is associated with pes planus has increases the Q-angle, which indirectly fluctuates the risk of patella subluxation.

Moreover, it is found that pes planus is commonly associated with other forms of musculoskeletal disease and deformities. In which, conditions such as hallux valgus, plantar fasciitis and back pain are commonly occur alongside with pes planus. Through studies, we had found that there is an association between the prevalence of hallux valgus and pes planus, where a negative correlation was found by Atbaşı et al. (2020) in between hallux valgus angle and calcaneal pitch angle. Calcaneal pitch angle below the normal range of 20^o to 32^o had been indicated with the presence of pes planus. This is due to the increased in loading at the medial and plantar aspect of the first ray during heel off, which is the result of increased pronation of the first ray, thus leading to the formation of hallux valgus (Ray et al., 2019). Furthermore, Park et al. (2018) had found that there is an association between pes planus and plantar fasciitis, where plantar fascia is found to have significant increase in thickness as compared to the normal arch foot, resulting in decrease of muscle strength, poses increase risk of plantar fasciitis to occur. On the other hand, low back pain had always been troubling 15% to 45% of the adults worldwide (World Health Organization., 2013). However, individuals with pes planus are more like to encounter acute low back pain and chronic low back pain by 3.28 times and 4.5 times more (Almutairi et al., 2021). In which, low back pain is found to have high prevalence of 65.9% among pes planus participants where 51.6% of them were suffering from acute low back pain while 48.4% of them were suffering from chronic low back pain (Almutairi et al., 2021).

Based on the above findings, pes planus will bring drastic effect to the affected individuals not only at the foot, but it will progress from the ankle until the lower back of the individuals. This is due to the fact that pes planus is found to increase the risk of ankle injuries, knee injuries and low back pain among the affected individuals. In addition, the disruption of foot biomechanics at the foot arch will lead to the development of other deformities and musculoskeletal conditions. For instances, genu valgum, hallux valgus and plantar fasciitis are found with high prevalence among individuals with pes planus. Thus, the presence of this complications along with pes planus had been problematic and disturbing to the affected individuals in their daily living, where it is found that QOL of these individuals had been significant reduced.

2.4 Relationship between Ankle Instability and Pes Planus

As mentioned above, the formation of this medial longitudinal arch deformity has negatively impacting on the individuals from several aspects.

However, the most important aspect that was affected by this defect within these individuals is stability. Stability is vital for an individual, as without stability, the individual will loss balance and encounter falls that will happens more frequently. Whereby, studies found that poor balancing had an association with the occurrence of ankle injuries. In which, participants who had greater scores for postural sway, indicating poor balancing, are found correlated to greater ankle injuries rate; and these subjects are found to have approximately seven times more with past history of ankle sprained compared to subjects which obtained good balancing scores (McGuine et al., 2000).

In the view of individuals with pes planus, the deformity of the foot arch had been a problematic factor for the balancing of these individuals, where study shows that 43% of these individuals are found to experience instability of the ankle (Dabholkar & Agarwal, 2020). This compromised aspect is said to be the primary factor for the cause of fall, resulting in the increasing risk and high prevalence of injury in lower limb, especially over ankle among individuals with pes planus. Several studies had found that individual with pes planus are more prone to instability in terms of static stability or dynamic stability, especially with the exclusion of visual input. These individuals are found to have significant decrease in stability when compare to individuals with normal arch of foot during the research (Tahmasebi et al., 2015; Sung et al., 2017; Koshino et al., 2020). Through studies, Sung et al. (2017) and Marouvo et al. (2021) had found that there is a significant decreased in dynamic stability with the exclusion of visual input among the pes planus individual. Whereas, static stability was found to be compromised among these individuals as the displacement of center of pressure (COP) was significant with $p < 0.05$ when compare with individuals of normal and high arch foot as found by Koshino et al. (2020) and a mean static balance measures that is significantly poorer in comparison between the pes planus individuals and control group where right leg was 25.70 versus 27.89 and left leg was 26.21 versus 28.52 was found by Adegoke et al. (2021).

From studies reviewed, it is observed that stability of an individual with pes planus had been severely affected either static stability or dynamic stability, this situation is even severe without the help of visual input. The reduction in stability will leads to the increasing risk of ankle injury sustained among the affected individuals.

2.4.1 Associating Factors – Achilles Tendon Contracture (ATC)

ATC is the functional tightness of gastrocnemius-soleus complex, causing reduction in length of the Achilles tendon. This shortening of the gastrocnemius-soleus complex may be the contributing factors for the formation of pes planus. According to Joseph et al. (2022), they described that ATC as one of the causal factors for the development of Type II flexible flat foot other than conditions that is associated with general ligamentous laxity such as Down's syndrome and Marfan syndrome. This is supported by findings found by Reimers et al. (1995), where Achilles tendon shortening is found present among all participants of teenagers with pes planus with a prevalence of 77% among adolescences age ranging from 11 to 17 years old, whereas among children age ranging from 2 to 5 years old is found to have a prevalence rate of 24%.

This shortening occurs within the gastrocnemius-soleus complex will creates negative impact by restricting the range of motion available over the ankle joint, especially dorsiflexion where it is found in 96.5% of the cases where heel flat is inhibited during gait cycle without any compensatory mechanism of the lower limb and foot (Hill, 1995; Gourdine-Shaw et al., 2010). Consequently, the rotation of the ankle is hindered and terminated in a shorten period. Nevertheless, the inertia causes the body to continues to propel forward over the planted foot, increasing the leveraged forces in the foot and ankle. Naturally, the ground reaction forces are inescapable and give this equation its balance. The leveraged pressures that arise are higher and occur earlier as the tighter the gastrocnemius-soleus complex becomes (Amis, 2016).

In addition, the tightening of this gastrocnemius-soleus complex is found to be positively correlated to plantar fasciitis, where the straining effect of Achilles tendon load acting on the plantar fascia is twice of the effect of body weight (Cheung et al., 2006). This, in which, indirectly compromised the stability of the pes planus individuals as individuals with plantar fasciitis are found more prone to postural sway with increasing complexity of task by $p < 0.01$ compare to healthy individuals (Petrofsky et al., 2020). As a result, individuals who are diagnosed with gastrocnemius-soleus complex tightness are said to be negatively correlated to the balance of an individual as studied by Endo & Sakamoto (2014), where the reach distance found with SEBT were significantly shorten in anterior, medial and lateral direction.

2.4.2 Associating Factors – Posterior Tibial Tendon Dysfunction (PTTD)

PTTD is always treated as the primary cause of adult acquired pes planus, as dysfunction over this tendon will impact on its support for the medial longitudinal arch, resulting in the collapse of arch along with excessive valgus deviation of the hindfoot (Abousayed et al., 2017). This happens due to the rupture of posterior tibial tendon that is either acute or traumatic in nature, which is sufficient to cause the damage on the foot arch before a complete rupture on the tendon had occur (Bubra et al., 2015). As the disease progresses, it will lead to the formation of valgus deviation, which will further progress into ATC due to lateral shift of the Achilles tendon from the normal axis (Bubra et al., 2015).

It is reported that PTTD had been affecting 3.3% to 10% of the population worldwide (Knapp & Constant, 2022). It has been a strong belief that PTTD is the causal factor of pes planus, whereby causal relationship seems to be shown in study conducted by Jahss (1991). Based on the findings, it is found that 100% of the patient with PTTD had pre-existing pes planus. However, study conducted by Kohls-Gatzoulis et al. (2009) found that among 37 participants with either pes planus or PTTD, five of them are encountering both the condition, showing prevalence of 13.51%. In which, it is contradictory to the finding from Jahss (1991).

Out of all the complications associated with PTTD, the most significant reduction among these individuals with the presence of PTTD is the stability of their ankle. This is because the posterior tibial tendon plays an important role for dynamic stabilization (Stein & Schon, 2015). Stabilization is only possible to be maintain with the presence of posterior tibial tendon, which is responsible for plantarflexion at the ankle joint, inversion at the subtalar joint, adduction and supination at the forefoot. During stance phase, it causes inversion over the hindfoot which maximizes the mechanical advantage of the Achilles tendon during toe off and causing adduction and plantarflexion of the navicular, thereby buttressing the medial longitudinal arch against disruption (Kapandji, 1970). In addition, part of this stabilization is achieved along with static stability contributed from the bony architecture and soft tissue structure. Hence, dysfunction occurring over the posterior tibial tendon will create an impact on the stability of the individual.

This theory is shown through study conducted by Wang et al. (2022), where individuals with PTTD had exhibited pronoun medially shifted center of pressure patterns than the control groups during swing phase. Besides, this group of individuals with PTTD had exhibited more conservative and cautious postural strategies in respond to instability. From the result, it shows that they experienced significantly higher double stance ratio and anteroposterior time to contact percentage than the control groups. In addition, they also showed significant decreased in medial-lateral centre of pressure velocity, which indicates that center of pressure of the individuals with PTTD tends to shift towards to the medial boundary during swing phase. Other than stability during gait, the static stability of individuals with PTTD is also found to be compromised. This is proven with study conducted by Kulig et al. (2015), where participants with PTTD in the study were found to have lesser success rate in performing testing USBT with prominent postural sway obtained during the test. Whereby, the participants with PTTD have pronoun increase of anteroposterior centre of pressure displacement and significant increase of medial-lateral centre of pressure displacement.

2.5 Assessment Method

2.5.1 Pes Planus

Although pes planus may be symptomatic, where it causes patient to complain of pain over the midfoot, heel, knee, hip pain and back pain, the continuous progression of this deformity may eventually lead to alteration in gait pattern among these individuals. However, most of the cases are asymptomatic, where the patient may not be aware of the presence of this deformity among themselves (Raj et al., 2022). Thus, foot screening is vital to screen for early diagnosis of this deformity among the affected individuals so that management can be applied to prevent and slow down the development of the complications.

Pes planus can be assessed either through clinical examination with the aid of assessment tools or through radiographic examination, which enable clinicians to diagnose the deformity correctly. Clinical examination that are available includes observation, Clarke's Angle (CA) and Chippaux-Smirek Index (CSI). Pes planus often presents with typical presentations where examiners can easily diagnose through observing the symptoms that pes planus individuals exhibit. On observation, the examiner will evaluate and compare both sides of the foot in weight-bearing and non-weight-bearing position (Raj et al., 2022). For flexible pes planus, the arch of the foot can be observed during non-weight-bearing positions. However, this arch of the foot will be unnoticeable as it disappears along with the transfer from non-weight bearing position into weight-bearing position on the foot (Raj et al., 2022). Moreover, the “too many toes” sign will be observed from the posterior view due to the excessive pronation that occurs as a result of the compensatory mechanism of the deformity (Raj et al., 2022).

Additionally, footprint printing is another alternative choice for the diagnosis of pes planus. With the use of angles obtained from the footprint of an individual such as CA and CSI, more accurate interpretation and diagnosis are able to be achieved in clinical settings without the use of expensive diagnostic tools. CA is the angle formed by the tangent at the medial margin of the footprint and the line straight line connecting the medial border of the foot and the contact point of the medial tangent to the forefoot (Pauk et al., 2014). According to Hegazy et al. (2022), CA demonstrates a higher sensitivity of 98.4%, specificity of 98.8% and intra-rater reliability of intraclass correlation coefficient (ICC)=0.99. Hegazy et al. (2021) also added that CA show greater validity than foot posture index-6 (FPI-6). However, this advantage does not appear to be the same when comparing CA with CSI. The study conducted by Gonzalez-Martin et al. (2018), found that CSI is capable to detect a higher prevalence of pes planus than CA where the sensitivity and specificity are found to be high as 87.6% and 88.4% (Chen et al., 2011). CSI of an individual is the product of 100% and the ratio of the widest part of the forefoot and the narrowest part of the midfoot (Tománková et al., 2015). An individual is classified as having pes planus if the

CSI value obtained is equal or greater than 45%. Apart from that, CSI is able to further classify the severity level of an individual into 3 different degrees, which are 1st degree, 2nd degree and 3rd degree with CSI value of 45.0% - 50.0%, 50.1% - 60.0% and 60.1% - 100.0% (Tománková et al., 2015).

For radiographic examination, weight-bearing lateral radiographs is the best view diagnosis and remains as the gold standard along with findings which are Meary's angle (MEa) and calcaneal inclination (CIa) (Raj et al., 2022). MEa is the angle formed between the 1st metatarsal and lateral talus from the lateral radiographs, while CIa is the angle formed between calcaneal inclination axis and the supporting surface. Pes planus is indicated if the values for MEa and CIa is greater than 4^{o} and lesser than 18^{o} (Al-Khudairi et al., 2019; Raj et al., 2022).

2.5.2 Ankle Instability

There are various ways to detect the ankle stability of an individual. In which tests that are commonly applied in the clinical settings are such as Balance Error Scoring System (BESS), SEBT and Y Balance test. However, out of these tests, Y balance test is frequently applied in most of the research due to its high reliability and easy accessibility to be conducted. Although BESS had been reported to have moderate to good reliability, even with large differences such as concussion and fatigue exist. However, when these differences become more subtle, this test will not be valid in defining the stability of an individual (Bell et al., 2011). Whereas, SEBT is a dynamic balancing test. With this aspect, it has increased the difficulties for examiners to accurately assess the measurement and the criteria in determining the need to repeat the test (Plisky et al., 2009). As a result, a simplified and enhanced version of the SEBT was invented, called Y balance test with the use of an instrument. According to Plisky et al. (2009), the Y balance test shows great intrarater reliability ranging from 0.85 to 0.91 and interrater reliability ranging from 0.99 to 1.00. Whereas, the composite reach score obtained a reliability of 0.91 for intrarater and 0.99 for interrater reliability.

2.5.3 ATC

In clinical settings, examiners tend to use Silfverskiold test to assess and differentiate between the contracture of gastrocnemius-soleus complex and gastrocnemius alone. Although the Silfverskiold test is commonly used in the clinical settings, however, it shows poor interrater and intrarater reliability testing with ICC values of 0.230 to 0.791 (Molund et al., 2018). However, the addition of maximum angle measurement for dorsiflexion with knee in 90º flexion and compare with knee in full extension may demonstrate more accurate result compare to Silfverskiold test alone. Individuals with Achilles tendon contracture will demonstrate limited range of ankle dorsiflexion due to the tightness occur in gastrocnemius-soleus complex. In which, the angle of dorsiflexion with knee flexed that achieved less than 10º is indicated with the presence of soleus muscles contracture, which in turns indicate the presence of Achilles tendon contracture (Bouchard & Mosca, 2014).

2.5.4 PTTD

Various ways can be used to assess the presence of PTTD among individuals with pes planus, such as using imaging tools like X-ray, ultrasound and magnetic resonance imaging (MRI). However, these screening tools are usually expensive and not accessible in the clinic settings where it is normal available only in hospitals. Thus, physical examination had been a more feasible method for examiners to access the presence of this dysfunction among the patient, which is known as single heel raise test (SHRT). According to Ross et al. (2021), SHRT test had achieved significant agreement between physiotherapist that it is most accurate test for PTTD with $\kappa = 0.74$; 95% CI: 0.54, 0.93. Individuals are said to be SHRT test positive with the presence of PTTD with either failure to perform heel raise or experiencing pain and difficulty during this test (Berlet et al., 2021).

2.6 Management for Pes Planus

Although the presence of pes planus may not be problematic to the individuals. However, prolonged adaptation of the other body structure will eventually pose other health issues for the individual. Hence, it is crucial to treat this deformity before it affects other areas. Management for pes planus are often conducted either conservatively, or surgically.

Conservative management is the first-line management, which includes ankle bracing, shoe insoles, foot orthotics and strengthening exercises

(Kodithuwakku Arachchige et al., 2019). These methods of management are reported to have a success rate of 67% to 90% (Abousayed et al., 2017). Although, despite modification in footwear had always been a myth to help in the arch of the foot. However, study conducted by Kanatlı et al. (2016) found that corrective shoes are ineffective to the development of foot arches among participants with pes planus. This finding is supported by review from Herchenröder et al. (2021), where different types of foot orthoses, such as custom-made foot orthoses, uniformly manufactured foot orthoses and semi-rigid foot orthoses were used in the studies. The authors concluded that no firm conclusion can be drawn regarding the positive effectiveness of the use of foot orthosis in managing pes planus. This is due to the lack of consistency between the studies and the lack of randomised controlled trials in investigating the effectiveness of the foot orthosis in treating individuals with pes planus, and it is flabbergasting that foot orthosis prescription to these affected individuals had been a common practice among the practitioners.

On the other hand, surgical management should be the last resort only when the conservation management fails to relieve the symptoms that exhibit, mainly pain. Surgical procedures that may be performed are such as soft tissue procedures, arthroereisis and osteotomies which are calcaneal lengthening osteotomy and calcaneo-cuboid cuneiform (Bouchard & Mosca, 2014).

2.7 Conclusion

Pes planus is a common foot deformity which had been bothersome to the affected individuals in several aspects. From literature reviewed, stability of the individuals, especially on the young adults had been negatively impacting them. In which, the increasing frequency of falls and recurrent ankle injuries had restricted them to participate in physical activities. Thus, it is important to address this complication as the withdrawal from physical activities will causes the arising of other health problem, such as increase of BMI index. Despite the fact that pes planus is found greatly influencing on the stability of the individuals, literature had shown that there are other factors that contributing to this increase of ankle instability, which are ATC and PTTD. However, the prevalence and causal relationship of PTTD and pes planus from the literature reviewed were contradictory to each other. It is unclear regarding the definite relationship in between PTTD and pes planus. In addition, there is limited study that discussed and tested regarding the influence and relationship for the presence of ATC or PTTD on the ankle stability of the individuals. Among the available studies, the assessment method and standard vary across each other. There is no uniform standard and conclusion that can be establish among these studies for us to refer. Furthermore, there is no study discussed regarding the effect of ATC and PTTD on ankle instability among individuals with pes planus. Studies available only discussed the presence of pes planus alone with ankle instability, but excluded other risk factors that may also contributing to the increase risk of ankle instability. Therefore, it is important to know regarding the additional presence of ATC and PTTD, whether is a necessary or sufficient factor that will lead to the increasing risk of ankle instability among the individuals with pes planus, especially among young adults. With the result obtained, a more targeting and effective treatment protocol other than just the use of corrective insoles alone can be established for the management of pes planus.

CHAPTER 3

MATERIALS AND METHODS

3.1 Chapter Overview

In this chapter, the study design, study setting, study population, sample size, sampling method, inclusion criteria, exclusion criteria, instrumentation, procedure, statistical analysis and ethical approval will be presented.

3.2 Study Design

The study design used for this study was a correlational study. Correlation study has the capability to examine event exposure, prevalence of a particular condition and risk factors in a population (Elwood, 2007). Hence, this study design is most suitable to apply for this study as researchers seek to study the correlation of Achilles tendon contracture and PTTD on ankle instability among young adults with pes planus. Quantitative data were collected by obtaining the data of foot arch, contracture of Achilles tendon contracture, PTTD and ankle instability through series of testing on the participants.

3.3 Study Setting

This study is conducted at Physiotherapy Exercise Laboratory (KA102), located at 1st floor of KA Block, Universiti Tunku Abdul Rahman (UTAR), Sungai Long campus.

3.4 Study Populations

The study populations that were selected in this study are young adults between the age of 18 to 25 years old with pes planus. These young adults included students who are pursuing their studies in foundations, bachelor degrees, and masters.

3.5 Sample Size

The sample size for this study was calculated by using the formula developed by (Krejcie & Morgan, 1970). The formula is as shown as below:

$$s = \frac{X^2 NP(1-P)}{d^2(N-1) + X^2 P(1-P)}$$

Where,

s = required samples size

X^2 = the table value of chi-square for 1 degree of freedom at the desired confidence level (3.841)

N = the population size

P = the population proportion (assumed to be .50 since this would provide the maximum sample size)

d = the degree of accuracy expressed as a proportion (.05)

The population size of this study is 7104 which indicated the total number of undergraduates in UTAR Sungai Long campus. With consideration of participants who might drop out from the study, 10% of the attrition rate is added to our sample size. Through calculation, the required sample size is calculated as 401 participants.

3.6 Sampling Method

Convenience and purposive sampling method are used in recruiting participants in this study. Convenience sampling method is the recruitment of participants who were conveniently to be access by researchers, whilst purposive sampling method is where the participants recruited were with specific characteristics defined that is relevant to the study. This combination of sampling method is a non-probability sample where probability of the population selection is known in advance, will produce result that are generalized to the subpopulations with the defined specific characteristics (Andrade, 2021).

3.7 Inclusion Criteria

Participants were included if they met the following criteria:

1. Age between 18 to 25 years old
2. Female and male
3. Presence of pes planus either unilaterally or bilaterally
4. Previous history of ankle injury occurred more than a month ago

3.8 Exclusion Criteria

Participants were excluded if they met the following criteria:

1. Previous history of surgery for corrections within past one month
2. Severe pain over the ankle
3. Acute ankle instability
4. Presence of oedema over the ankle joint
5. Previous history of medial collateral ligament or lateral collateral ligament injuries

3.9 Instrumentation

Instruments that is used for this study are stadiometer, footprint ink, A3 paper, basins, measuring tape, goniometer, plinth and Y balance test kit.

3.9.1 Stadiometer

A stadiometer is an anthropometric instrument which was used to measure the height and weight of the participants with accuracy up to one decimal point. This is to access regarding the BMI index of the participants. Before standing on the stadiometer, participants were instructed to remove all the objects that may vary the measurement such as shoes, watch, handphones and wallet. Then, the participants were instructed to stand on the stadiometer against the wall while facing forward for the measurement of height and weight. The measurements the reading on the stadiometer were obtained and recorded in the participants' assessment form (attached as **Appendix G**).

Figure 3.1: SECA Stadiometer (Mod 220).

3.9.2 Footprint ink and paper

Footprints were used to access the footprint of the participants with the aim to screen for the presence of pes planus among the participants. In order to obtain the footprint, participants immersed their foot into the footprint ink and their footprints are printed on an A3 paper (297mm x 420mm). At the same time, it acts as a screening tool to exclude participants who are free from pes planus. The footprint ink was made with mixture of poster colour inks and water while ensuring that the viscosity of the ink is high and not too watery throughout the data collection period as it will affect the footprint and CSI value.

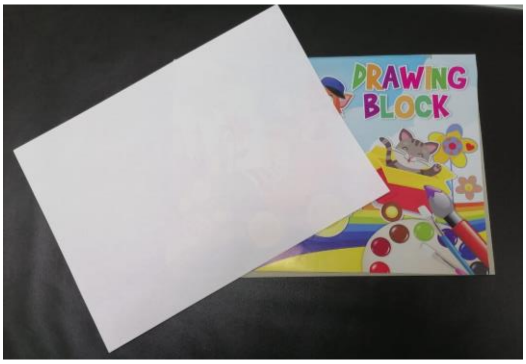

Figure 3.2: A3 Paper.

Figure 3.3: Poster Colors for the Footprint Ink.

3.9.3 Basin

Two basins were used in this study. Where one of the basins was used to filled with the ink for the footprint printing, while the other basin was filled with clear water to allow the participants to wash their feet after printing their footprints.

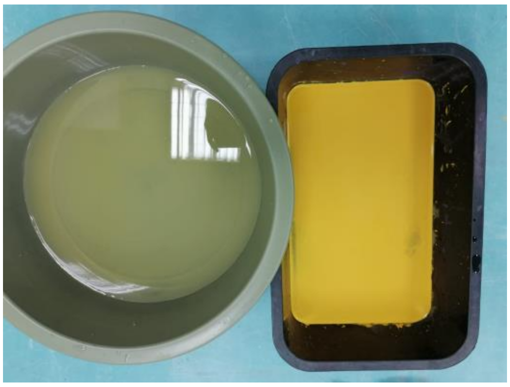

Figure 3.4: The Basin on the Left contains Clean Water while the Basin on the Right contains the Footprint Ink.

3.9.4 Measuring tape

A measuring tape with maximum of 150 cm was used in this study. The measuring tape was used for 2 purposes, which are for the footprints and for the limb length. For the footprint, it is used to measure the length of narrowest width of the foot arch (A) and the length of the widest width of the metatarsals (B). While taking the readings of these measurement, the measuring tape is ensured that the two lengths were parallel to each other for accurate data production. These recorded measurements were obtained by measuring from the footprints printed by the participants and were used in order to obtain the CSI value and classification of the foot arch. On the other hand, the limb length of the participants was obtained through measurement with the use of the measuring tape. The measuring tape was place on the two reference points, the ASIS and medial malleolus of the participants.

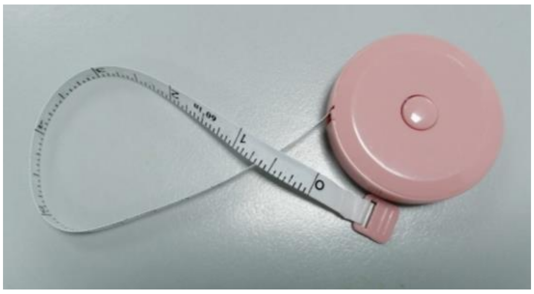

Figure 3.5: Measuring Tape.

3.9.5 Goniometer

A goniometer with two arms, distal arm and proximal arm, and a fulcrum with scale that can extend from 0º to 360º on full circles mode. The goniometer was used in this study to obtain the angle of ankle dorsiflexion of the participants during knee flexed and knee extension on both right and left sides of the ankle. The angle of dorsiflexion was measured by placing the goniometer on the lateral aspect of the ankle, where the fulcrum was placed on the distal lateral malleolus, proximal arm place parallel to the imaginary line from lateral malleolus to fibular head and distal arm was placed parallel from lateral malleolus to the central of the 5th metatarsal head.

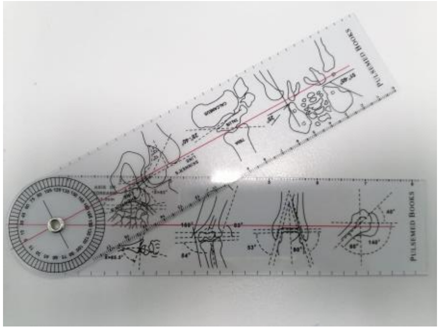

Figure 3.6: Goniometer.

3.9.6 Plinth

One plinth was used during the measurement of limb length and dorsiflexion angle. The limb length was obtained when participants is in supine lying position which is used for the calculation of balancing composite score. Whereas, for the measurement of dorsiflexion angle to test the present of Achilles tendon contracture, it is used to position participants in supine lying throughout this measurement taking.

Figure 3.7: Plinth.

3.9.7 Y Balance Test Kit

A Y balance test kit was used in this study in order to conduct the Y balance test and to determine the stability of the participants. The Y balance test kit consisted of three pipes in three different direction, which are anterior, posteromedial and posterolateral. Both posterior pipes were positioned 135º away from the anterior pipe while 45º is kept in between the posterior pipes.

Figure 3.8: Y Balance Test Kit.

3.10 Procedure

After obtaining ethical approval from UTAR Scientific and Ethical Review Committee (SERC), the process of data collecting began and lasted for 2 weeks. Young adults who are currently enrolled in any undergraduate programmes in Sungai Long campus of UTAR were approached through physical recruitment and online platforms with poster promotion (**Figure 3.9**) such as WhatsApp, Instagram and Microsoft Teams.

Figure 3.9: Poster used for Participant Recruitment.

The registered participants where then added into a WhatsApp group where the date, venue and instructions prior attending the data collection were announced through. This research was carried out in Physiotherapy Exercise Laboratory (KA102), 1st floor, KA Block, UTAR Sungai Long Campus and lasted for 8 days. Before the start of the procedure, a briefing regarding the overall research procedure was given to the participants. Afterwards, the consent form and demographic data was distributed to the participants to fill in with the use of google form (attached as **Appendix F**) as to proved that they are willing to take part in this research and to provide necessary information that are required for the use of data analysis. Participants were then led to take measurements of their height in meters and weight in kilograms, the measurements were recorded down as shown in **Figure 3.10**. The BMI index of the participants were then calculated with the use of the measurement obtained by applying the formula, $BMI = \frac{mass\ (kg)}{height^2\ (m)}$. Afterwards, the dominant side of the participants was determined and identified first through a simple testing by pushing the participant from the back and observed the side of the leg which stepped out first to stabilized themselves. The leg which stepped out first after the push was determined as the dominant leg. Moving on, initial assessment was conducted in order to filter and eliminate individuals based on the pre-set inclusion and exclusion criteria.

Figure 3.10: Weight and Height Measurement Taking.

For pes planus screening, CSI of the individual was obtained where footprints of the participants were printed out first with the use of footprint ink. After cleaning their feet, participants stepped on the ink prepared in a basin (shown in **Figure 3.11**), then the footprints were printed by stepping on a piece of A3 paper with full weight bearing on both legs as in **Figure 3.12** (Gonzalez-Martin et al., 2017). Afterwards, the participants were allowed to wash their feet by using the prepared clean water in the basin. From the footprints, 2 values were obtained from the footprint: (1) length A – at the narrowest point of the foot arch and (2) length B – the widest width at the metatarsals (shown in **Figure 3.14**).

Then, CSI is calculated using the formula, $CSI = \frac{A}{B} \times 100\%$. According to Onodera et al. (2008), participants with CSI of 45% or above were classified as pes planus and will proceed to the following stations. Whereas, participants who obtained below 45% were notified with their findings where 0% indicates foot with elevated arch, 0.1% to 29.9% was indicated with normal foot arch, 30% to 39.9% was indicated as intermediate foot and 40% to 44.9% was indicated as foot with a lowered arch.

Figure 3.11: Participant stepped on the Basin filled with Ink.

Figure 3.12: Participant printing their Footprint in Weightbearing Position.

Figure 3.13: Example of Footprint Printed Out from the Participants.

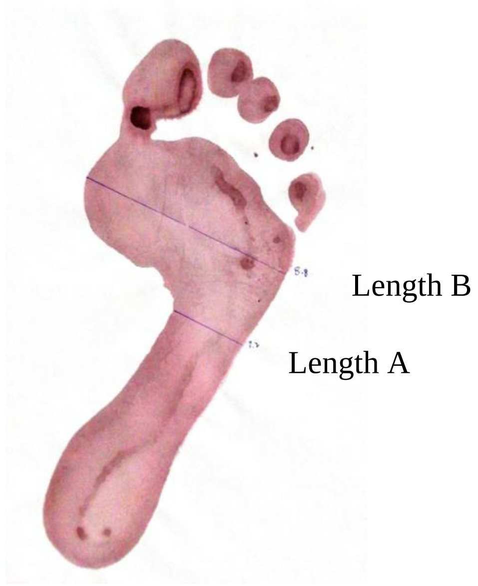

Figure 3.14: Measurement for CSI value.

For the participants who met the criteria to proceed, they were brought to the first station which is to assess for the presence of ATC. ATC was assessed through measuring the angle of dorsiflexion of the participants during knee flexed and knee extended position. Participants were positioned in supine lying, and they were instructed to do maximum dorsiflexion with knee in 90º flexion and full extension. The placement of the goniometer was on the lateral aspect of the ankle as shown in **Figure 3.15** and **Figure 3.16**, where the fulcrum was placed on the distal lateral malleolus, proximal arm place parallel to the imaginary line from lateral malleolus to fibular head and distal arm was placed parallel from lateral malleolus to the central of the 5th metatarsal head. ATC was identified as present when dorsiflexion angle is found to be less than 10° and 20° when knee is in extended and flexed position (Molund et al., 2018).

Figure 3.15: Position of goniometer during Knee Extension.

Figure 3.16: Position of goniometer during Knee Flexion.

The second station was to assess for the presence of posterior tibial tendon dysfunction among these participants. SHRT was performed among these participants to evaluate the presence of PTTD. This test was conducted in barefoot, where participants will be asked to perform single leg heel raise on one side first, then repeatedly perform on the alternate side as shown in **Figure 3.17**. Failure to perform heel raise or experiencing pain and difficulty by the participant during this test was indicated as positive (Berlet et al., 2021).

Figure 3.17: Participant with Their Heel Raised on Single Leg during the SHRT.

If participants are found to have either one or both of the tested risk factors, they will be guided to the last station which is the balancing test. For participants who were found negative from both of the tested variables, they are allowed to leave after being notified with their findings from the previous stations. The balancing kit consist of three pipes for three reach direction, which are anterior, posteromedial and posterolateral. Both posterior pipes are places 135º away from the anterior pipe while 45º is kept in between the posterior pipes.

This test was conducted with sport shoe wore. The participants pushed the reach indicator to the furthest distance they can reach while maintaining their testing foot flat on the ground as indicated in **Figure 3.18**, **Figure 3.19** and **Figure 3.20**. The distance in between the indicator and the center of foot plate is measured and recorded down. A demonstration was performed to the participants, then the participants will be allowed with six trials per foot prior actual testing to practice and familiarize with the test. For the start of the test, participants should perform three trials on each foot from same direction for both feet and repeating to the subsequent direction, this action is to enhancing the consistency of the test (Plisky et al., 2009). The participant was considered to fail the test if they failed to maintain balance during unilateral stance on the platform, failed to maintain reach foot contact with the reach indicator during movement, using the reach indicator to support during stance or failed to return the free foot to starting position under control; repetition or termination of the test is then required.

Next, the lower limb length was measured as well in order for the calculation of composite score. Participants were positioned in supine lying, after performing pelvic squaring by raising the hip of the participants of the plinth and place it back down with knee extended (**Figure 3.21**). The true length of the participants' limb was measured in centimetres with taking reference point of anterior superior iliac spine (ASIS) and distal tip of medial malleolus (**Figure 3.22**). Once all measurements were obtained, the composite score was calculated by applying the formula as below.

$$Composite\ score\ (\%)$$

$$= [sum\ of\ average\ reach\ distance\ in\ 3\ directions$$

$$\div (limb\ length\ in\ cm \times 3)] \times 100$$

Participants who scores a composite score of 89.99% or below are consider to have poor stability, as it is proven to have a sensitivity of 100% (Butler et al.,2013).

Figure 3.18: Participant performing Y balance test in Anterior Direction of Right Leg.

Figure 3.19: Participant performing Y balance test in Posteromedial Direction of Right Leg.

Figure 3.20: Participant performing Y balance test in Posterolateral Direction of Right Leg.

Figure 3.21: Procedure of Pelvic Squaring before obtaining the measurement of limb length.

Figure 3.22: Procedure of Limb Length Measurement on the Left Limb with ASIS and Medial Malleolus as Reference Point.

3.11 Statistical Analysis

Data collected was computed and analysed using IBM Statistical Package for the Social Science (SPSS) version 26 software. The produced data findings were coded using Microsoft Excel. Demographic data such as age, gender, height and weight were analysed through descriptive statistics. Whereas, the correlation between the ATC and PTTD on ankle instability among young adults was analysed through Pearson's Chi-Square and Fisher's Exact Test.

3.12 Ethical Approval

This study was subjected to the ethical approval from UTAR Scientific and Ethical Review Committee (SERC). An ethical approval letter (Re: U/SERC/224/2022) was provided after the approval and it was attached in **Appendix A**. The informed consent form containing the introduction of the research was also attached in **Appendix E**. All of the participants were notified that their information and responses were kept confidential at all times and their participation in the study should be completely voluntary. Hence, participants preserved the right to withdraw from the study at any time and the researcher has no authority to reject their withdrawal.

CHAPTER 4

RESULTS

4.1 Chapter Overview

In this chapter, the findings and statistical analysis will be presented. The demographic data of the participants is presented first, followed by the findings and correlation between ATC and PTTD on ankle instability.

4.2 Demographic Data of the Participants

The researchers had successfully recruited 177 participants for this study through physical recruitment and poster promotion via online platforms such as WhatsApp, Instagram and Microsoft Teams. However, only 80 of these participants met the criteria with history of ankle sprains which occurred more than a month ago, and another one of these participants had reported with history of medial collateral ligament or lateral collateral ligament injuries. After our screening session, 57 out of 79 participants were found with pes planus. Hence, data from the remaining 57 participants was analysed.

Table 4.1: Demographic Data of the Participants.

	n (%)	Mean ± SD
n	57 (100.0)	
Age		20.46 ± 1.310
18	6 (10.5)	
19	6 (10.5)	
20	15 (26.3)	
21	19 (33.3)	
22	8 (14.0)	
23	3 (5.3)	
Gender		
Male	31 (54.4)	
Female	26 (45.6)	
Height (m)		1.67 ± 0.089
Weight (kg)		65.43 ± 15.283
BMI (kgm^{-2})		23.32 ± 4.641
BMI Category		
Overweight and obese	20 (35.1)	
Normal	37 (64.9)	
Awareness for Presence of Pes Planus		
Unaware	41 (71.9)	
Aware	16 (28.1)	
Activity level		
None	7 (12.3)	
Moderate	28 (49.1)	
Active	17 (29.8)	
Very Active	5 (8.8)	
Sport(s) involved		
None	8 (14.3)	
Badminton	16 (28.6)	
Basketball	9 (16.1)	
Aerobic Exercises	9 (16.1)	
Martial Art	3 (5.4)	
Volleyball	1 (1.8)	
Swimming	1 (1.8)	
> 1 Sport	9 (16.1)	
Frequency of Sport(s) Participations		
None	7 (12.3)	
Once a week	27 (47.4)	
Twice a week	9 (15.8)	

Table 4.1: Demographic Data of the Participants (Cont').

≥ Three times a week	14 (24.6)

Note: n = Total number of participants; BMI = Body Mass Index; SD = Standard Deviation

Table 4.1 above shows the frequency and percentage for the distribution of participants in the view of age, gender, BMI category, activity level, sports involvement and frequency of sport participation. Whereas, the distribution of participants in the view of age, height, weight and BMI score were presented with mean and standard deviation in the table.

4.2.1 Age Distribution of Participants

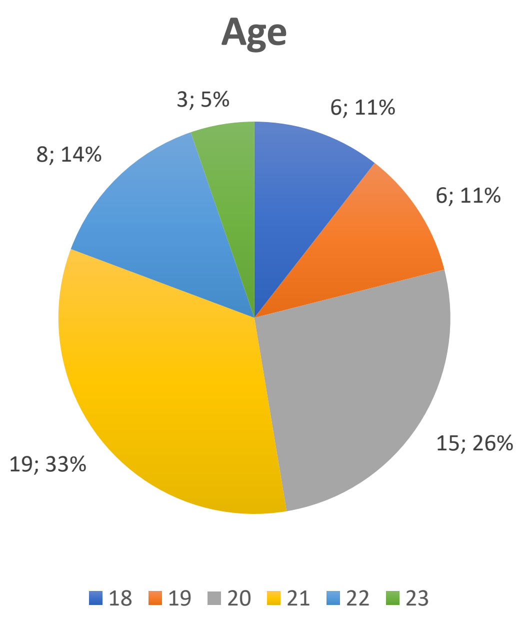

Figure 4.1: Distribution of Age of Participants.

Figure 4.1 above illustrates the age distribution of the participants involved in this study. According to **Table 4.1**, the age of the participants in this study has achieved a mean age of 20.46 ± 1.310 years. After exclusion, none of the participants were found to be in the age of 24 and 25 years. Majority of them were in the age of 21 years, which made up of 33.3% of the participants with a frequency of 19 out of 57 participants. Minority of the participants were in the age of 23 years, which made up of 5.3% of the total participants with a frequency of 3 out of 56 participants. Whereas, the distribution of the other age was 10.5% (6 participants) for age of 18 years, 10.5% (6 participants) for age of 19 years, 26.3% (15 participants) for age of 20 years and 14.0% (8 participants) for age of 22 years respectively.

4.2.2 Gender Distribution of Participants

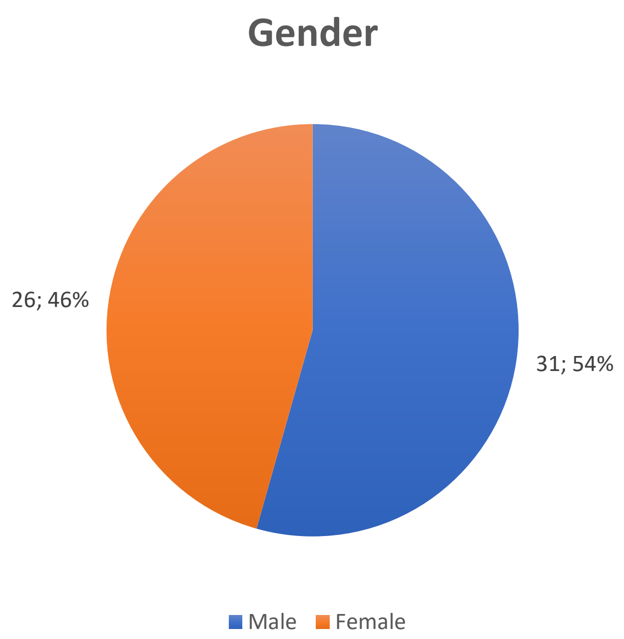

Figure 4.2: Distribution of Gender of Participants.

Figure 4.2 presents the gender distribution of the participants involved in this study. According to **Table 4.1,** majority of the participants were made of male young adults which is 54.4% with a frequency of 31 participants. On the other hand, female young adults had made up of 45.6% with a frequency of 26 of the total participants.

4.2.3 BMI Category Distribution of Participants

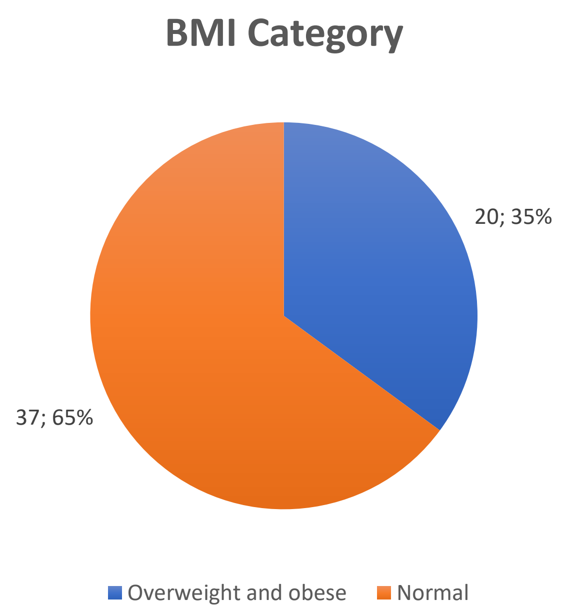

Figure 4.3: Distribution of BMI Category of Participants.

Figure 4.3 presents the gender distribution of the participants involved in this study. Based on **Table 4.1**, the mean height and weight obtained were 1.67 ± 0.089 kg and 65.43 ± 15.283 m. With this, the mean BMI score obtained with through calculation was 23.32 ± 4.641 kgm^{-2}. By referring to **Figure 4.3**, it is observed that more than half of the participants were classified as normal with a frequency of 37 participants (64.9%). Whereas, 20 participants (35.1%) were categorized as overweight and obese with BMI value over 25 kgm^{-2}.

4.2.4 Activity Level of Participants

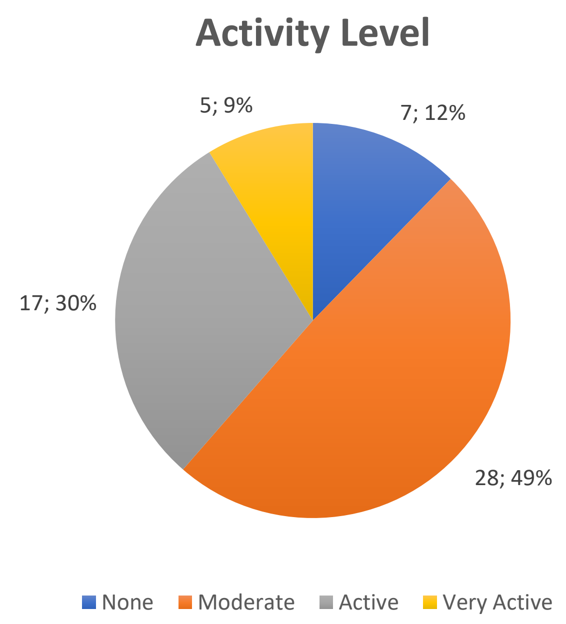

Figure 4.4: Distribution of Activity Level of Participants.

Figure 4.4 illustrates the distribution of activity level of the participants involved in this study. In reference to **Table 4.1** and **Figure 4.4**, it can be concluded that majority of the participants had reported with moderate level of activity with a percentage of 49.1% (n=28). Whereas, the distribution for the other level of activity are 12.3% (n=7) without any activity, 29.8% (n=17) to be active and 8.8% (n=5) to be very active.

4.2.5 Sports Involvement by the Participants

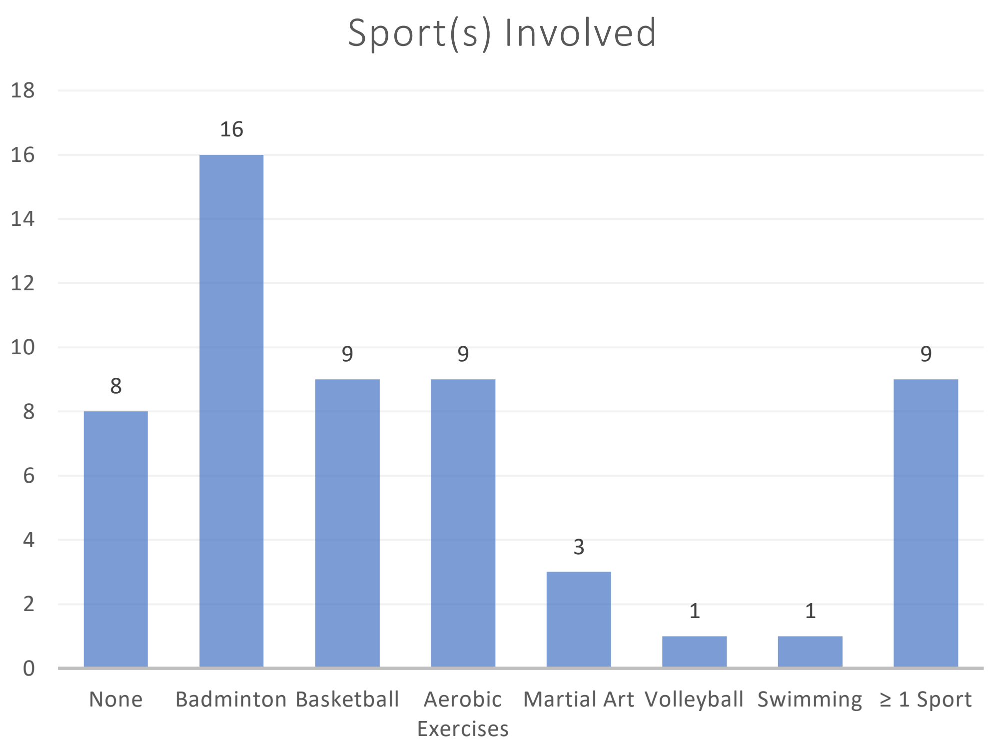

Figure 4.5: Distribution of Sports Involvement by the Participants.

Figure 4.5 demonstrates the distribution of sports involved by the participants. By referring to **Table 4.1** and **Figure 4.5**, it is found that majority of the participants were involved in badminton which had made up of 28.1% (n=16) in this study. Whereas, only one participant was involved in volleyball and swimming respectively, thus both these sports made up of 1.8% respectively. The remaining sports that were involved by the participants are such as basketball with 9 participants (15.8%), aerobic exercises with 10 participants (17.5%) and martial art with 3 participants (5.3%). It is found that 9 participants (15.8%) had reported to involved in more than one sport. However, 8 of the total participants (14.0%) had reported that they did not involve in any of the sport.

4.2.6 Frequency of Sport(s) Participations by the Participants

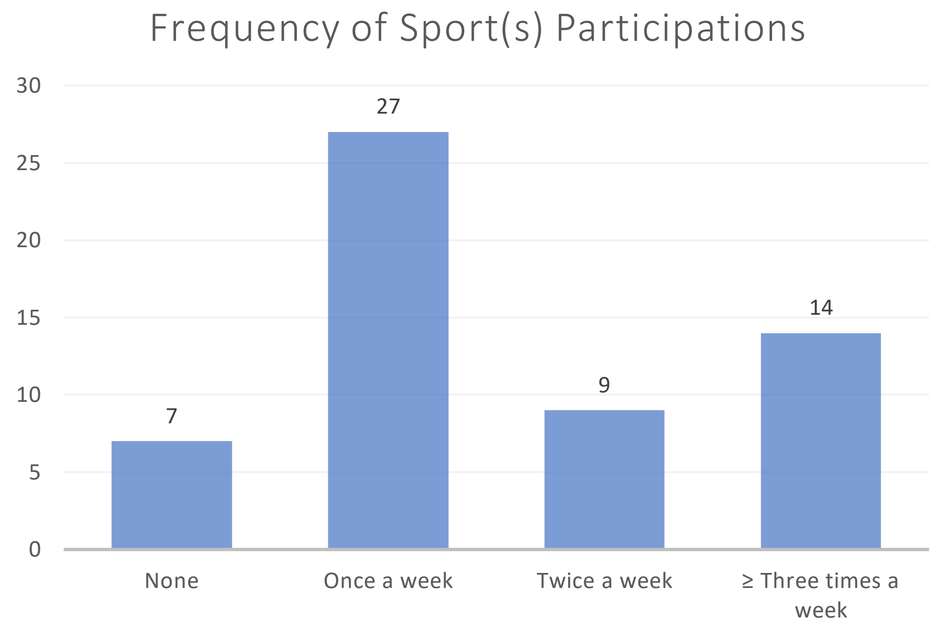

Figure 4.6: Frequency of Sport(s) Participations Distribution of the Participants.

Figure 4.6 presents the frequency of sport(s) participations of the participants. Most of the participants were found to participate in their respective sport for once a week, where there are a total number of 27 (47.4%). While, minority of the participants were found to have none participants at all in a week by a total number of 7 (12.3%). Besides, the participants whom have sport participations for twice a week had reached a percentage of 15.8% (n=9), while participants with frequency of three or more times a week take up 24.6% of the total participants (n=14).

4.3 Outcome Measures among All Participants

Table 4.2: Outcome Measures among All Participants

	n (%)	Mean ± SD
n	57 (100.0)	
CSI (%)		
Right		57.18 ± 14.552
Left		62.48 ± 14.953
Degree of Severity (Right)		
None	7 (12.3)	
1st Degree	18 (31.6)	
2nd Degree	14 (24.6)	
3rd Degree	18 (31.6)	
Degree of Severity (Left)		
None	5 (8.8)	
1st Degree	12 (21.1)	
2nd Degree	11 (19.3)	
3rd Degree	29 (50.9)	
Leg Dominance		
Right	34 (59.6)	
Left	23 (40.4)	
Nature of Pes Planus		
Unilateral – Right	5 (8.8)	
Unilateral – Left	7 (12.3)	
Bilateral	45 (78.9)	
ATC or PTTD		
None of ATC and PTTD	4 (7.0)	
ATC only	19 (33.3)	
PTTD only	10 (17.5)	
Both ATC and PTTD	24 (42.1)	
Ankle Stability		
Instability	37 (64.9)	
Normal	20 (35.1)	

Note: n = total number of participants; ATC = Achilles Tendon Contracture; PTTD = Posterior Tibial Tendon Dysfunction; SD = Standard Deviation.

Table 4.2 summarized the general findings for CSI value, degree of severity, leg dominance, nature of pes planus, ATC, PTTD and ankle instability among all 57 participants.

4.3.1 Degree of Severity among Participants

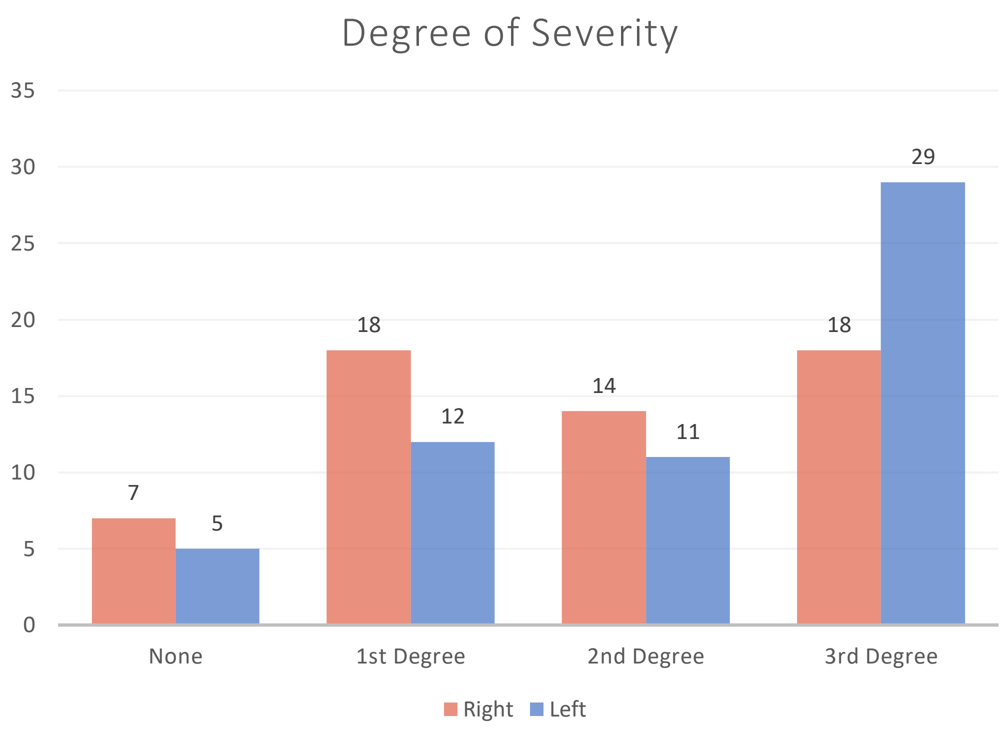

Figure 4.7: Distribution of Pes Planus Degree of Severity on the Right and Left Foot.

Figure 4.7 shows the distribution of participants according to degree of severity on the right and left foot. From **Table 4.2**, it is reported that the CSI value of all the participants achieved a mean value of 57.18% ± 14.552 on the right foot and range of 54.80%. While for the left foot, it had achieved a mean value of 62.48% ± 14.953 on the left foot and range of 51.86%. Based on the CSI value, the participants were further categorized as 1st degree with CSI between 45.0% - 50.0%, 2nd degree with CSI between 50.1% - 60.0%, and 3rd degree with CSI between 60.1% - 100.0%. It is found that the participants who are categorized as 1st degree are 31.6% (n=18) for the right foot and 21.1% (n=12) for the left foot. While for the participants who are categorized as 2nd degree are

24.6% (n=14) for the right foot and 19.3% (n=11) for the left foot. Meanwhile, participants who are categorized as 3rd degree had the most number, where 31.6% (n=18) for the right foot and 50.9% (n=29) for the left foot. However, for the participants who are tested having pes planus unilaterally with CSI below 45% are 12.3% from the right foot and 8.8% for the left foot.

4.3.2 Leg Dominance among Participants

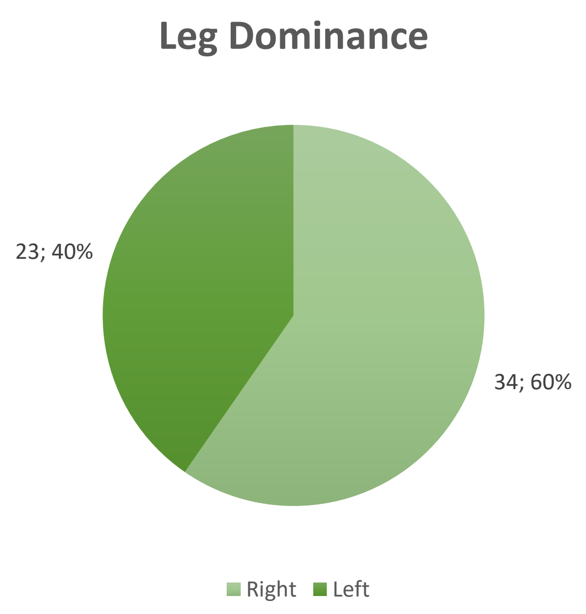

Figure 4.8: Distribution of Leg Dominance among Participants.

Figure 4.8 shows the distribution of leg dominance among the participants. According to the **Table 4.2** and **Figure 4.8**, it is shown that majority of the participants are tested with the right foot as their dominant leg by 59.6% (n=34). Whereas, remaining 40.4% (n=23) of the participants had their dominant leg on the left side.

4.3.3 Nature of Pes Planus among Participants

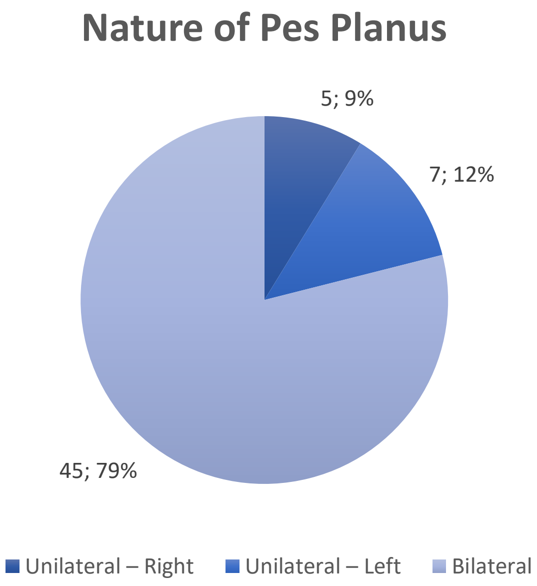

Figure 4.9: Distribution of Nature of Pes Planus among Participants.

Figure 4.9 demonstrates the distribution of the nature of pes planus among all participants. From **Table 4.2**, it is found that most of the participants were diagnosed with pes planus as bilaterally by 78.9%. Whereas, the remaining 12 participants were to have pes planus as unilaterally. In which, pes planus occurring on the right side consist 8.8% (n=5) and on the left side consist 12.3% (n=7).

4.3.4 Presence of ATC or PTTD among Participants

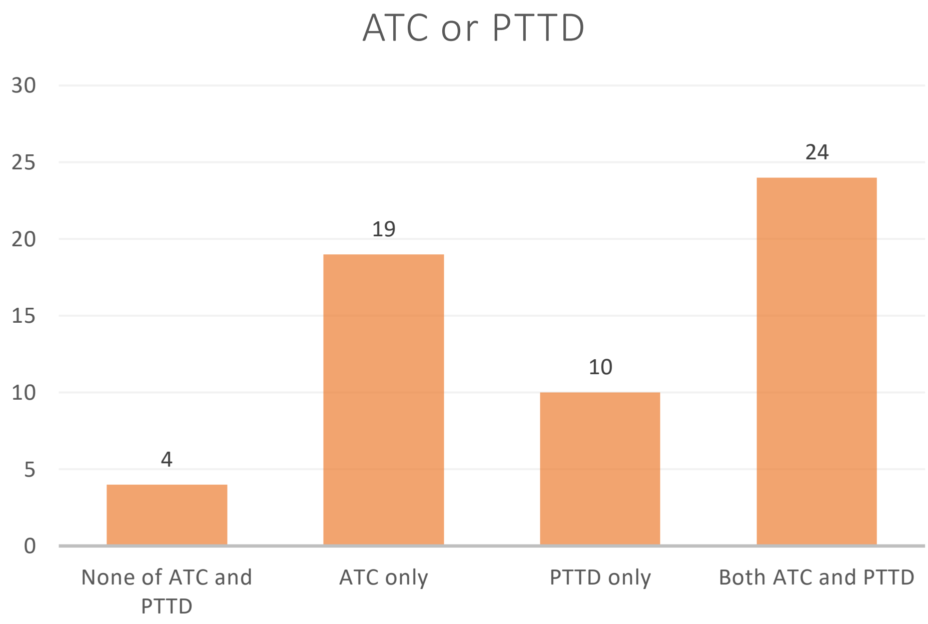

Figure 4.10: Distribution of Presence of ATC or PTTD among Participants.

Figure 4.10 presents with the distribution of ATC or PTTD among all the participants. Based on **Table 4.2** and **Figure 4.10**, it is observed that majority of the participants where tested with the presence of both ATC and PTTD with a frequency of 24 (42.1%). Whereas, only 4 of the participants where tested free from both ATC and PTTD (7.0%). Apart from that, participants who were tested with the presence of ATC alone is greater than participants who were tested with presence of PTTD alone with 19 participants (33.3%) compare to 10 participants (17.5%).

4.3.5 Presence of Ankle Instability among Participants

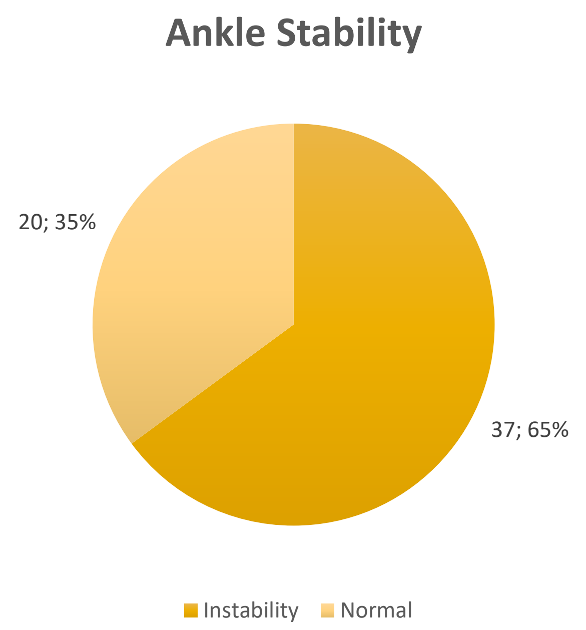

Figure 4.11: Distribution of Presence of Ankle Instability among Participants.

Figure 4.11 presents with the distribution of ankle instability among all the participants. Based on **Table 4.2** and **Figure 4.11**, it is observed that majority of the participants fall in the category of ankle instability, with a percentage of 64.9% (n=37). Whereas, the remaining 35.1% of the participants fall in the category of normal stability of the ankle.

4.4 Gender, Leg Dominance, Achilles Tendon Contracture, PTTD and Ankle Instability Distribution Among Participants based on Degree of Severity

Table 4.3: Distribution Among Participants Based on Degree of Severity.

	Degree of Severity					
	Right Foot			Left Foot		
	1st Degree	2nd Degree	3rd Degree	1st Degree	2nd Degree	3rd Degree
n	18 (100.0%)	14 (100.0%)	18 (100.0%)	12 (100.0%)	11 (100.0%)	29 (100.0%)
CSI Value (%)	46.88 ± 0.948	53.71 ± 2.655	76.12 ± 9.542	47.02 ± 1.539	53.98 ± 2.212	75.41 ± 8.632
BMI (kgm^{-2})	22.05 ± 2.887	23.62 ± 6.371	24.88 ± 4.896	22.67 ± 2.666	22.76 ± 3.529	23.99 ± 5.863
Gender						
Male	8 (44.4%)	9 (64.3%)	11 (61.1%)	5 (41.7%)	6 (54.5%)	17 (58.6%)
Female	10 (55.6%)	5 (35.7%)	7 (38.9%)	7 (58.3%)	5 (45.5%)	12 (41.1%)

Table 4.3: Distribution Among Participants Based on Degree of Severity (Cont').

Leg Dominance						
Right	13 (72.2%)	9 (64.3%)	9 (50.0%)	10 (83.3%)	4 (36.4%)	16 (55.2%)
Left	5 (27.8%)	5 (35.7%)	9 (50.0%)	2 (16.7%)	7 (63.6%)	13 (44.8%)
ATC or PTTD						
None of ATC and PTTD	5 (27.8%)	3 (21.4%)	4 (22.2%)	1 (8.3%)	1 (9.1%)	5 (17.2%)
ATC only	5 (27.8%)	4 (28.6%)	6 (33.3%)	8 (66.7%)	8 (72.1%)	10 (34.5%)
PTTD only	3 (16.7%)	1 (7.1%)	6 (33.3%)	2 (16.7%)	1 (9.1%)	6 (20.7%)
Both ATC and PTTD	5 (27.8%)	6 (42.9%)	2 (11.1%)	1 (8.3%)	1 (9.1%)	8 (27.6%)
Ankle Stability						
Instability	12 (66.7%)	9 (64.3%)	8 (44.4%)	9 (75.0%)	5 (45.5%)	18 (62.1%)
Normal	6 (26.1%)	5 (35.7%)	10 (55.6%)	3 (25.0%)	6 (54.5%)	11 (37.9%)

Note: n = total number of participants; CSI = Chippaux-Smirak Index; BMI = Body Mass Index; ATC = Achilles Tendon Contracture; PTTD = Posterior Tibial Tendon Dysfunction.

Table 4.3 presents with the findings and distribution of CSI value, BMI index, gender, leg dominance, nature of pes planus, presence of either ATC or PTTD or both, and presence of ankle instability based on the severity level of the participants. From the **Table 4.3**, it is shown that 62.1% (n=18) of the participants with 3rd degree of severity on the left foot had ankle instability. However, the participants with 3rd degree of severity on right foot show different finding where only 44.4% (n=8) of them are having ankle instability. Additionally, pes planus that occurring on the left foot showed slightly higher prevalence of ankle instability than the right side with 32 foots compare to 29 foots.

4.5 Gender, Leg Dominance, Achilles Tendon Contracture, PTTD and Ankle Instability Distribution Among Participants based on Nature of Pes Planus

Table 4.4: Distribution Among Participants Based on Nature of Pes Planus.

	Nature of Pes Planus		
	Unilateral - Right	Unilateral - Left	Bilateral
n	5 (100.0%)	7 (100.0%)	45 (100.0%)
CSI (%)			
Right	44.30 ± 3.846		60.61 ± 14.440
Left	51.56 ± 13.13		65.40 ± 14.151
Gender			
Male	3 (60.0%)	3 (42.9%)	25 (55.6%)
Female	2 (40.0%)	4 (57.1%)	20 (44.4%)
Leg Dominance			
Right	4 (80.0%)	3 (42.9%)	27 (60.0%)
Left	1 (20.0%)	4 (57.1%)	18 (40.0%)
ATC or PTTD			
None of ATC and PTTD	1 (20.0%)	1 (14.3%)	2 (4.4%)
ATC only	3 (60.0%)	3 (42.9%)	13 (28.9%)
PTTD only	0 (0.0%)	1 (14.3%)	9 (20.0%)
Both ATC and PTTD	1 (20.0%)	2 (28.6%)	21 (46.7%)
Ankle Stability			
Instability	4 (80.0%)	5 (71.4%)	28 (62.2%)
Normal	1 (20.0%)	2 (28.6%)	17 (37.8%)

Note: n = total number of participants; ATC = Achilles Tendon Contracture; PTTD = Posterior Tibial Tendon Dysfunction.

Table 4.4 summarized and compare the findings for gender, leg dominance, Achilles tendon contracture, PTTD and ankle instability among the different nature pes planus groups of 57 participants.

4.5.1 Pes Planus Distribution within Genders

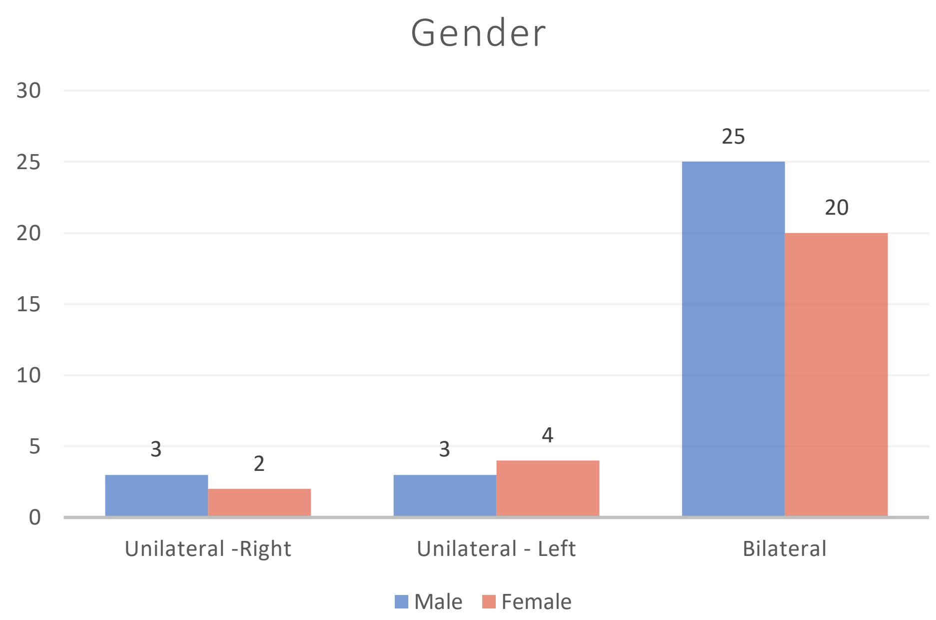

Figure 4.12: Distribution of Genders among Participants with Pes Planus.

Figure 4.12 presents with the distribution of genders of participants among participants with different nature of pes planus. By comparing between both the genders, male young adults tend to have slightly higher prevalence of pes planus compare to female young adults. Whereby the total number of pes planus among male young adults had achieved 31 out of 57 participants, making up a percentage of 54.4%. While the total number of pes planus among female young adults are 26 out of 5 participants, making up a percentage of 45.6%. Within the males, it is observed that majority of the participants pes planus as bilaterally by 80.6% (n=25). While the males with pes planus that occur unilaterally only take up 9.7% each either on the right side or left side. By looking into the females, pes planus which occur bilaterally is comparative lesser than the males, with a percentage of 76.9% (n=20). Whereas, females with pes planus that occur unilaterally take up 7.7% (n=2) on the right side and 15.4% (n=4) on the left side.

4.5.2 Pes Planus Distribution on Dominant Side of Participants

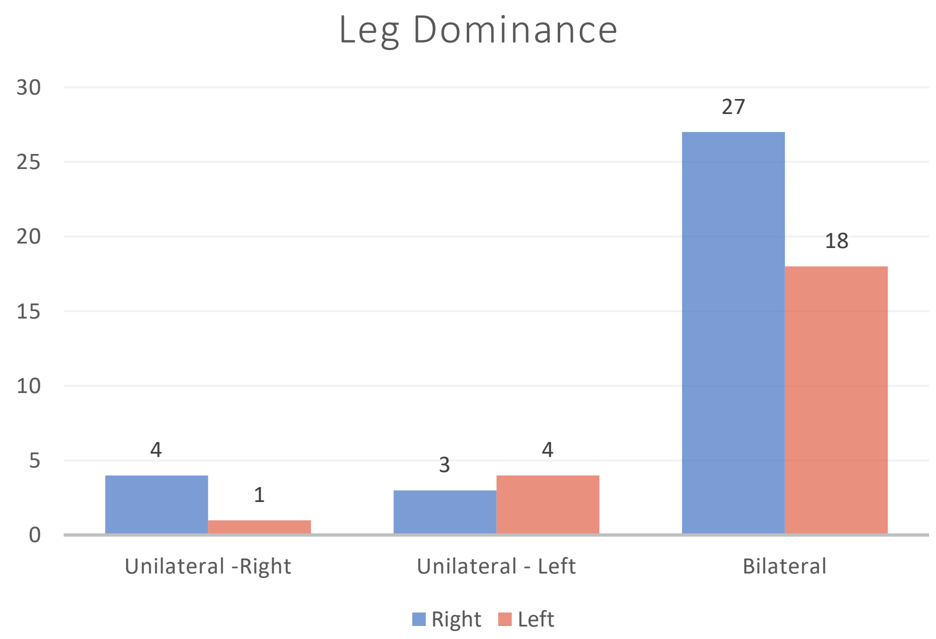

Figure 4.13: Distribution of Pes Planus on Dominant Side of Participants.

Figure 4.13 illustrates the distribution of pes planus that occur on the dominant side of the participants. From **Table 4.4**, it is presented that 34 of the participants were tested with dominant side on the right, whereby 31 of them were having pes planus on the right side. In which, unilateral pes planus participants contributed 11.8% (n=4) and bilateral pes planus participants contributed 79.4% (n=27). On the other hand, 23 of the participants were tested with dominant side on the left, whereby 22 of them were having pes planus on the left side. In which, unilateral pes planus participants contributed 17.4% (n=4) and bilateral pes planus participants contributed 78.3% (n=18).

4.5.3 Presence of ATC or PTTD among Pes Planus Participants

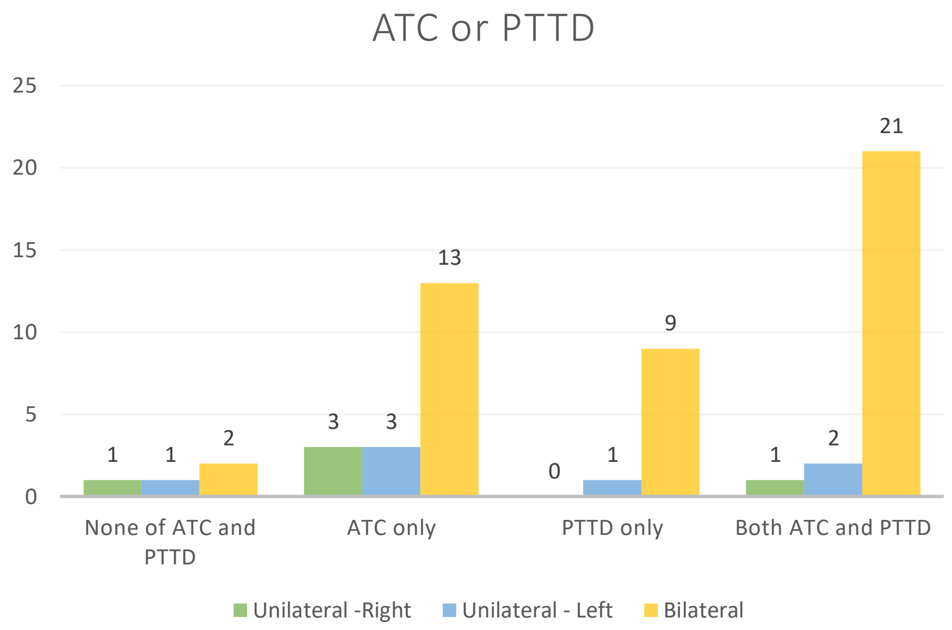

Figure 4.14: Distribution of Presence of ATC or PTTD among Participants with Pes Planus.

Figure 4.14 illustrates the distribution of participants with the presence of ATC or PTTD among participants with different nature of pes planus. From the **Table 4.4**, it is found that participants who are free from both the ATC or PTTD are only 20.0% (n=1) from unilateral right side, 14.3% (n=1) from unilateral left side and 4.4% (n=4) from bilateral. Whereas, participants who had presence of both the ATC and PTTD are 20.0% from unilateral right side, 28.6% (n=2) from unilateral left and 46.7% (n=21) from bilateral. Apart from that, participants who had the presence of ATC alone are 60.0% (n=3) from unilateral right side, 42.9% (n=3) from unilateral left side and 28.9% (n=13) from bilateral. Lastly, participants who had presence of PTTD alone are 0.0% (n=0) from unilateral right, 14.3% (n=1) from unilateral left side and 20.0% (n=9) from bilateral.

4.5.4 Ankle Instability among Pes Planus Participants

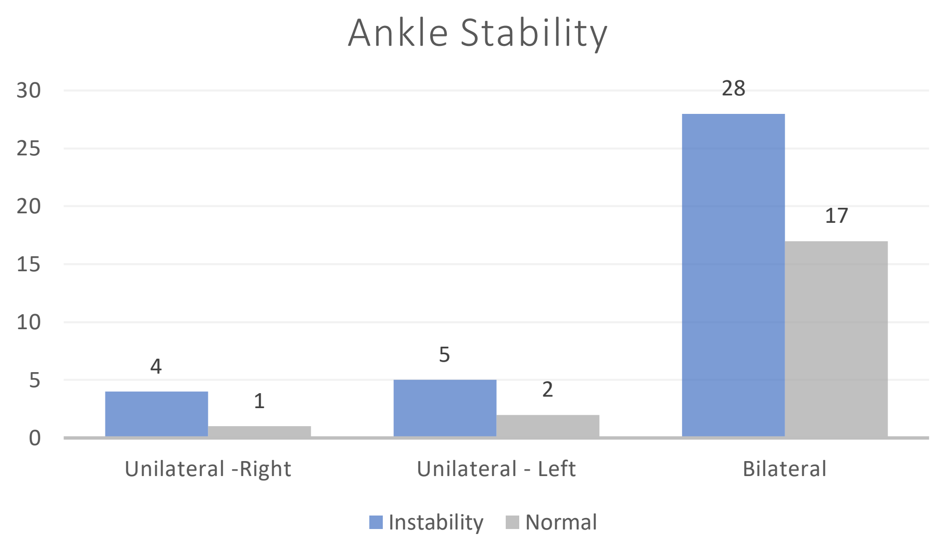

Figure 4.15: Distribution of Ankle Instability among Participants with Pes Planus.

Figure 4.15 presents with the distribution of ankle instability among the participants with different nature of pes planus. By referring to both **Table 4.4** and **Figure 4.16** it is found that 28 out of 45 of the participants had ankle instability within participants with bilateral pes planus, consisting up to 62.2% of the bilateral pes planus participants. On the other hand, the participants with unilateral pes planus on right side were found to have 80% of the participants (n=4) had ankle instability. While, the participants with unilateral pes planus on left side were found to have 13.5% of the participants (n=5) had ankle instability.

4.6 Correlation between ATC and PTTD with Ankle Instability among all Pes Planus Participants

Table 4.5: Correlation between ATC and Ankle Instability among all Pes Planus Participants.

Presence of ATC	Ankle Stability		χ^2/FET	df	*p-value*
	Normal	Instable			
	n (%)	n (%)			
Yes	6 (31.6%)	13 (68.4%)	0.154	1	.695
No	14 (36.8%)	24 (63.2%)			

Note: Chi-Square Test was performed. n = number of participants; ATC = Achilles Tendon Contracture; df = degree of freedom. Level of significant at $p > 0.05$.

The correlation between ATC alone and ankle instability among all pes planus participants is presented in **Table 4.5**. Among participants who were tested with the presence of ATC alone, the prevalence of ankle instability was 68.4% (n=13) while the prevalence of normal ankle stability was 31.6% (n=6). Among the participants who were tested without the presence of ATC alone, the prevalence of ankle instability was 63.2% (n=24) while the prevalence of normal ankle stability was 36.8% (n=14). Chi-square test was performed and the result was χ^2 /FET = 0.154 and sig- χ^2 (*p-value*) = 0.695. Since *p-value* is more than 0.05, there is no significant correlation between ATC alone and ankle instability among all pes planus participants in the present study.

Table 4.6: Correlation between PTTD and Ankle Instability among all Pes Planus Participants.

Presence of PTTD	Ankle Stability		χ^2/FET	df	*p-value*
	Normal	Instable			
	n (%)	n (%)			
Yes	1 (10.0%)	9 (90.0%)	-	-	.082
No	19 (40.4%)	28 (59.6%)			

Note: Fisher's Exact test was performed. n = number of participants; PTTD = Posterior Tibial Tendon Dysfunction; df = degree of freedom. Level of significant at p > 0.05.

The correlation between PTTD alone and ankle instability among all pes planus participants is presented in **Table 4.6**. Among participants who were tested with the presence of PTTD alone, the prevalence of ankle instability was 90.0% (n=9) while the prevalence of normal ankle stability was 10.0% (n=1). Among the participants who were tested without the presence of PTTD alone, the prevalence of ankle instability was 59.6% (n=28) while the prevalence of normal ankle stability was 40.4% (n=19). Fisher's Exact test was performed as 25.0% of the cells had expected count less than 5. With this, there was no result obtained for χ^2 /FET, while result for sig- χ^2 (*p-value*) = 0.082. Since *p-value* is more than 0.05, there is no significant correlation between PTTD alone and ankle instability among all pes planus participants in the present study.

Table 4.7: Correlation between Both ATC and PTTD with Ankle Instability among all Pes Planus Participants.

Presence of Both ATC and PTTD	Ankle Stability		χ^2/FET	df	*p-value*
	Normal	Instable			
	n (%)	n (%)			
Yes	11 (45.8%)	13 (54.2%)	2.102	1	.147
No	9 (27.3%)	24 (72.7%)			

Note: Chi-Square test was performed. n = number of participants; ATC = Achilles Tendon Contracture; PTTD = Posterior Tibial Tendon Dysfunction; df = degree of freedom. Level of significant at p > 0.05.

The correlation between both ATC and ankle instability among all pes planus participants is presented in **Table 4.7**. Among participants who were tested with the presence of both ATC and PTTD, the prevalence of ankle instability was 54.2% (n=13) while the prevalence of normal ankle stability was 45.8% (n=11). Among the participants who were tested without the presence of both ATC and PTTD, the prevalence of ankle instability was 72.7% (n=24) while the prevalence of normal ankle stability was 27.3% (n=9). Chi-square test was performed and the result was χ^2 /FET = 2.102 and sig- χ^2 (*p-value*) = 0.147. Since *p-value* is more than 0.05, there is no significant correlation between both ATC and PTTD with ankle instability among all pes planus participants in the present study.

4.7 Correlation between ATC and PTTD with Ankle Instability among Unilateral Pes Planus Participants

Table 4.8: Correlation between ATC and Ankle Instability among Unilateral Pes Planus Participants.

Presence of ATC	Ankle Stability		χ^2/FET	df	*p-value*
	Normal	Instable			
	n (%)	n (%)			
Yes	0 (0.0%)	6 (100.0%)	-	-	.182
No	3 (50.0%)	3 (50.0%)			

Note: Fisher's Exact test was performed. n = number of participants; ATC = Achilles Tendon Contracture; df = degree of freedom. Level of significant at $p > 0.05$.

The correlation between ATC only and ankle instability among unilateral pes planus participants is illustrated in **Table 4.8**. Among participants who were tested with the presence of ATC alone, the prevalence of ankle instability was 100.0% (n=6) while the prevalence of normal ankle stability was 0.0% (n=0). Among the participants who were tested without the presence of ATC alone, the prevalence of ankle instability and prevalence of normal ankle instability was both 50.0% (n=3) respectively. Fisher's Exact test was performed as 100.0% of the cells had expected count less than 5. With this, there was no result obtained for χ^2 /FET, while result for sig- χ^2 (*p-value*) = 0.182. Since *p-value* is more than 0.05, there is no significant correlation between the ATC alone and ankle instability among unilateral pes planus participants in the present study.

Table 4.9: Correlation between PTTD and Ankle Instability among Unilateral Pes Planus Participants.

Presence of PTTD	Ankle Stability		χ^2/FET	df	*p-value*
	Normal	Instable			
	n (%)	n (%)			
Yes	3 (27.3%)	8 (72.7%)	-	-	1.000
No	0 (0.0%)	1 (100.0%)			

Note: Fisher's Exact test was performed. n = number of participants; PTTD = Posterior Tibial Tendon Dysfunction; df = degree of freedom. Level of significant at p > 0.05.

The correlation between PTTD alone and ankle instability among unilateral pes planus participants is illustrated in **Table 4.9**. Among participants who were tested with the presence of PTTD alone, the prevalence of ankle instability normal ankle stability was 100.0% (n=1) and prevalence of normal ankle stability was 0.0% (n=0). Among the participants who were tested without the presence of PTTD alone, the prevalence of prevalence of ankle instability was 72.7% (n=8) while the prevalence of normal ankle stability was 27.3% (n=3). Fisher's Exact test was performed as 75.0% of the cells had expected count less than 5. With this, there was no result obtained for χ^2 /FET, while result for sig-χ^2 (*p-value*) = 1.000. Since *p-value* is more than 0.05, there is no significant correlation between the PTTD and ankle instability among unilateral pes planus participants in the present study.

Table 4.10: Correlation between Both ATC and PTTD with Ankle Instability among Unilateral Pes Planus Participants.

Presence of Both ATC and PTTD	Ankle Stability		χ^2/FET	df	*p-value*
	Normal	Instable			
	n (%)	n (%)			
Yes	2 (66.7%)	1 (33.3%)	-	-	.127
No	1 (11.1%)	8 (88.9%)			

Note: Fisher's Exact test was performed. n = number of participants; ATC = Achilles Tendon Contracture; PTTD = Posterior Tibial Tendon Dysfunction; df = degree of freedom. Level of significant at p > 0.05.

The correlation between both ATC and ankle instability among unilateral pes planus participants is presented in **Table 4.10**. Among participants who were tested with the presence of both ATC and PTTD, the prevalence of ankle instability was 33.3% (n=1) while the prevalence of normal ankle stability was 66.7% (n=2). Among the participants who were tested without the presence of both ATC and PTTD, the prevalence of ankle instability was 88.9% (n=8) while the prevalence of normal ankle stability was 11.1% (n=1). Fisher's Exact test was performed as 75.0% of the cells had expected count less than 5. With this, there was no result obtained for χ^2 /FET, while result for sig- χ^2 (*p-value*) = 0.127. Since *p-value* is more than 0.05, there is no significant correlation between the ATC and PTTD with ankle instability among unilateral pes planus participants in the present study.

4.8 Correlation between ATC and PTTD with Ankle Instability among Bilateral Pes Planus Participants

Table 4.11: Correlation between ATC and Ankle Instability among Bilateral Pes Planus Participants.

Presence of ATC	Ankle Stability		χ^2/FET	df	*p-value*
	Normal	Instable			
	n (%)	n (%)			
Yes	6 (46.2%)	7 (53.8%)	-	-	.511
No	14 (34.4%)	21 (65.6%)			

Note: Fisher's Exact test was performed. n = number of participants; ATC = Achilles Tendon Contracture; df = degree of freedom. Level of significant at $p > 0.05$.

The correlation between ATC alone and ankle instability among unilateral pes planus participants is illustrated in **Table 4.11**. Among participants who were tested with the presence of ATC alone, the prevalence of ankle instability was 53.8% (n=7) while the prevalence of normal ankle stability was 46.2% (n=6). Among the participants who were tested without the presence of ATC alone, the prevalence of ankle instability was 65.6% (n=21) while the prevalence of normal ankle stability was 34.4% (n=11). Fisher's Exact test was performed as 25.0% of the cells had expected count less than 5. With this, there was no result obtained for χ^2 /FET, while result for sig- χ^2 (*p-value*) = 0.511. Since *p-value* is more than 0.05, there is no significant correlation between the ATC alone and ankle instability among bilateral pes planus participants in the present study.

Table 4.12: Correlation between PTTD and Ankle Instability among Bilateral Pes Planus Participants.

Presence of PTTD	Ankle Stability		χ^2/FET	df	*p-value*
	Normal n (%)	Instable n (%)			
Yes	1 (11.1%)	8 (88.9%)	-	-	.122
No	16 (44.4%)	20 (55.6%)			

Note: Fisher's Exact test was performed. n = number of participants; PTTD = Posterior Tibial Tendon Dysfunction; df = degree of freedom. Level of significant at p > 0.05.

The correlation between PTTD alone and ankle instability among bilateral pes planus participants is shown in **Table 4.12**. Among participants who were tested with the presence of PTTD alone, the prevalence of ankle instability was 88.9% (n=8) while the prevalence of normal ankle stability was 11.1% (n=1). Among the participants who were tested without the presence of PTTD alone, the prevalence of ankle instability was 55.6% (n=20) while the prevalence of normal ankle stability was 44.4% (n=16). Fisher's Exact test was performed as 25.0% of the cells had expected count less than 5. With this, there was no result obtained for χ2 /FET, while result for sig- χ2 (p-value) = 0.122. Since *p-value* is more than 0.05, there is no significant correlation between the PTTD alone and ankle instability among bilateral pes planus participants in the present study.

Table 4.13: Correlation between Both ATC and PTTD with Ankle Instability among Bilateral Pes Planus Participants.

Presence of Both ATC and PTTD	Ankle Stability		χ^2/FET	df	*p-value*
	Normal	Instable			
	n (%)	n (%)			
Yes	9 (42.9%)	12 (57.1%)	0.432	1	.511
No	8 (33.3%)	16 (66.7%)			

Note: Chi-Square test was performed. n = number of participants; ATC = Achilles Tendon Contracture; PTTD = Posterior Tibial Tendon Dysfunction; df = degree of freedom. Level of significant at p > 0.05.

The correlation between both ATC and ankle instability among bilateral pes planus participants is presented in **Table 4.13**. Among participants who were tested with the presence of both ATC and PTTD, the prevalence of ankle instability was 57.1% (n=12) while the prevalence of normal ankle stability was 42.9% (n=9). Among the participants who were tested without the presence of both ATC and PTTD, the prevalence of ankle instability was 66.7% (n=16) while the prevalence of normal ankle stability was 33.3% (n=8). Chi-square test was performed and the result was χ^2 /FET = 0.432 and sig- χ^2 (*p-value*) = 0.511 Since *p-value* is more than 0.05, there is no significant correlation between both ATC and PTTD with ankle instability among bilateral pes planus participants in the present study.

4.9 Correlation between ATC and PTTD with Ankle Instability among Pes Planus on Dominant Leg of Participants

Table 4.14: Correlation between ATC and Ankle Instability among Pes Planus on Dominant Leg of Participants.

Presence of ATC	Ankle Stability		χ^2/FET	df	*p-value*
	Normal	Instable			
	n (%)	n (%)			
Yes	6 (31.6%)	13 (68.4%)	0.075	1	.784
No	12 (35.3%)	22 (64.7%)			

Note: Chi-Square test was performed. n = number of participants; ATC = Achilles Tendon Contracture; df = degree of freedom. Level of significant at $p > 0.05$.

The correlation between ATC alone and ankle instability among participants with pes planus that occur on dominant leg is demonstrated in **Table 4.14**. Among participants who were tested with the presence of ATC alone, the prevalence of ankle instability was 68.4% (n=13) while the prevalence of normal ankle stability was 31.6% (n=6). Among the participants who were tested without the presence of ATC alone, the prevalence of ankle instability was 64.7% (n=22) while the prevalence of normal ankle stability was 35.3% (n=12). Chi-square test was performed and the result was χ^2 /FET = 0.075 and sig- χ^2 (*p-value*) = 0.784. Since *p-value* is more than 0.05, there is no significant correlation between ATC alone and ankle instability among participants with pes planus that occur on dominant leg in the present study.

Table 4.15: Correlation between PTTD and Ankle Instability among Pes Planus on Dominant Leg of Participants.

Presence of PTTD	Ankle Stability		χ^2/FET	df	*p-value*
	Normal	Instable			
	n (%)	n (%)			
Yes	1 (10.0%)	9 (90.0%)	-	-	.137
No	17 (39.5%)	26 (60.5%)			

Note: Fisher's Exact test was performed. n = number of participants; PTTD = Posterior Tibial Tendon Dysfunction; df = degree of freedom. Level of significant at $p > 0.05$.

The correlation between PTTD alone and ankle instability among participants with pes planus that occur on dominant leg is demonstrated in **Table 4.15**. Among participants who were tested with the presence of PTTD alone, the prevalence of ankle instability was 90.0% (n=9) while the prevalence of normal ankle stability was 10.0% (n=1). Among the participants who were tested without the presence of PTTD alone, the prevalence of ankle instability was 60.5% (n=26) while the prevalence of normal ankle stability was 39.5% (n=17). Fisher's Exact test was performed as 75.0% of the cells had expected count less than 5. With this, there was no result obtained for χ^2 /FET, while result for sig-χ^2 (*p-value*) = 0.137. Since *p-value* is more than 0.05, there is no significant correlation between PTTD alone and ankle instability among participants with pes planus that occur on dominant leg in the present study.

Table 4.16: Correlation between Both ATC and PTTD with Ankle Instability among Pes Planus on Dominant Leg of Participants.

Presence of Both ATC and PTTD	Ankle Stability		χ^2/FET	df	*p-value*
	Normal	Instable			
	n (%)	n (%)			
Yes	10 (45.5%)	12 (54.5%)	2.215	1	.137
No	8 (25.8%)	23 (74.2%)			

Note: Chi-Square test was performed. n = number of participants; ATC = Achilles Tendon Contracture; PTTD = Posterior Tibial Tendon Dysfunction; df = degree of freedom. Level of significant at p > 0.05.

The correlation between both ATC and ankle instability among participants with pes planus that occur on dominant leg is presented in **Table 4.16**. Among participants who were tested with the presence of both ATC and PTTD, the prevalence of ankle instability was 54.5% (n=12) while the prevalence of normal ankle stability was 45.5% (n=10). Among the participants who were tested without the presence of both ATC and PTTD, the prevalence of ankle instability was 74.2% (n=23) while the prevalence of normal ankle stability was 25.8% (n=8). Chi-square test was performed and the result was χ^2 /FET = 2.215 and sig- χ^2 (*p-value*) = 0.137. Since *p-value* is more than 0.05, there is no significant correlation between both ATC and PTTD with ankle instability among participants with pes planus that occur on dominant leg in the present study.

4.10 Correlation between ATC and PTTD with Ankle Instability among Participants with 3rd Degree of Severity of Pes Planus

Table 4.17: Correlation between ATC and Ankle Instability among Participants with 3rd Degree of Severity of Pes Planus on Right Foot.

Presence of ATC	Ankle Stability		χ^2/FET	df	*p-value*
	Normal n (%)	Instable n (%)			
Yes	3 (50.0%)	3 (50.0%)	-	-	1.000
No	7 (58.3%)	5 (41.7%)			

Note: Fisher's Exact test was performed. n = number of participants; ATC = Achilles Tendon Contracture; df = degree of freedom. Level of significant at $p > 0.05$.

The correlation between ATC alone and ankle instability among participants with 3rd degree of severity of pes planus on the right foot is presented in **Table 4.17**. Among participants who were tested with the presence of ATC alone, the prevalence of ankle instability and normal ankle stability was 50.0% (n=3) respectively. Among the participants who were tested without the presence of ATC alone, the prevalence of ankle instability was 41.7% (n=5) while the prevalence of normal ankle stability was 58.3% (n=7). Fisher's Exact test was performed as 7.0% of the cells had expected count less than 5. With this, there was no result obtained for χ^2 /FET, while result for sig- χ^2 (*p-value*) = 1.000. Since *p-value* is more than 0.05, there is no significant correlation between ATC alone and ankle instability among participants with 3rd degree of severity of pes planus on the right foot in the present study.

Table 4.18: Correlation between ATC and Ankle Instability among Participants with 3rd Degree of Severity of Pes Planus on Left Foot.

Presence of ATC	Ankle Stability		χ^2/FET	df	*p-value*
	Normal n (%)	Instable n (%)			
Yes	3 (30.0%)	7 (70.0%)	-	-	0.694
No	8 (42.1%)	11 (57.9%)			

Note: Fisher's Exact test was performed. n = number of participants; ATC = Achilles Tendon Contracture; df = degree of freedom. Level of significant at $p > 0.05$.

The correlation between ATC alone and ankle instability among participants with 3rd degree of severity of pes planus on the left foot is demonstrated in **Table 4.18**. Among participants who were tested with the presence of ATC alone, the prevalence of ankle instability was 70.0% (n=7) while the prevalence of normal ankle stability was 30.0% (n=3). Among the participants who were tested without the presence of ATC alone, the prevalence of ankle instability was 57.9% (n=11) while the prevalence of normal ankle stability was 42.1% (n=8). Fisher's Exact test was performed as 25.0% of the cells had expected count less than 5. With this, there was no result obtained for χ^2 /FET, while result for sig- χ^2 (*p-value*) = 0.694. Since *p-value* is more than 0.05, there is no significant correlation between Achilles tendon contracture alone and ankle instability among participants with 3rd degree of severity of pes planus on the left foot in the present study.

Table 4.19: Correlation between PTTD and Ankle Instability among Participants with 3rd Degree of Severity of Pes Planus on Right Foot.

Presence of PTTD	Ankle Stability		χ^2/FET	df	*p-value*
	Normal	Instable			
	n (%)	n (%)			
Yes	3 (50.0%)	3 (50.0%)	-	-	1.000
No	7 (58.3%)	5 (41.7%)			

Note: Fisher's Exact test was performed. n = number of participants; PTTD = Posterior Tibial Tendon Dysfunction; df = degree of freedom. Level of significant at $p > 0.05$.

The correlation between PTTD alone and ankle instability among participants with 3rd degree of severity of pes planus on the right foot is presented in **Table 4.19**. Among participants who were tested with the presence of PTTD alone, the prevalence of ankle instability and normal ankle stability was 50.0% (n=3) respectively. Among the participants who were tested without the presence of PTTD alone, the prevalence of ankle instability was 41.7% (n=5) while the prevalence of normal ankle stability was 58.3% (n=7). Fisher's Exact test was performed as 50.0% of the cells had expected count less than 5. With this, there was no result obtained for χ^2 /FET, while result for sig- χ^2 (*p-value*) = 1.000. Since *p-value* is more than 0.05, there is no significant correlation between the PTTD alone and ankle instability among participants with 3rd degree of severity of pes planus on the right foot in the present study.

Table 4.20: Correlation between PTTD and Ankle Instability among Participants with 3rd Degree of Severity of Pes Planus on Left Foot.

Presence of PTTD	Ankle Stability		χ^2/FET	df	*p-value*
	Normal	Instable			
	n (%)	n (%)			
Yes	2 (33.3%)	4 (66.7%)	-	-	1.000
No	9 (39.1%)	14 (60.9%)			

Note: Fisher's Exact test was performed. n = number of participants; PTTD = Posterior Tibial Tendon Dysfunction; df = degree of freedom. Level of significant at $p > 0.05$.

The correlation between PTTD alone and ankle instability among participants with 3rd degree of severity of pes planus on the left foot is demonstrated in **Table 4.20**. Among participants who were tested with the presence of PTTD alone, the prevalence of ankle instability was 66.7% (n=4) while the prevalence of normal ankle stability was 33.3% (n=2). Among the participants who were tested without the presence of PTTD alone, the prevalence of ankle instability was 60.9% (n=14) while the prevalence of normal ankle stability was 39.1% (n=9). Fisher's Exact test was performed as 50.0% of the cells had expected count less than 5. With this, there was no result obtained for χ^2 /FET, while result for sig- χ^2 (*p-value*) = 1.000. Since *p-value* is more than 0.05, there is no significant correlation between PTTD alone and ankle instability among participants with 3rd degree of severity of pes planus on the left foot in the present study.

Table 4.21: Correlation between Both ATC and PTTD with Ankle Instability among Participants with 3rd Degree of Severity of Pes Planus on Right Foot.

Presence of Both ATC and PTTD	Ankle Stability		χ^2/FET	df	*p-value*
	Normal	Instable			
	n (%)	n (%)			
Yes	1 (50.0%)	1 (50.0%)	-	-	1.000
No	9 (56.2%)	7 (43.8%)			

Note: Fisher's Exact test was performed. n = number of participants; ATC = Achilles Tendon Contracture; PTTD = Posterior Tibial Tendon Dysfunction; df = degree of freedom. Level of significant at p > 0.05.

The correlation between both ATC and ankle instability among participants with 3rd degree of severity of pes planus on the right foot is presented in **Table 4.21**. Among participants who were tested with the presence of both ATC and PTTD, the prevalence of ankle instability and prevalence of normal ankle stability was 50.0% (n=1) respectively. Among the participants who were tested without the presence of both ATC and PTTD, the prevalence of ankle instability was 43.8% (n=7) while the prevalence of normal ankle stability was 56.2% (n=9). Fisher's Exact test was performed as 50.0% of the cells had expected count less than 5. With this, there was no result obtained for χ^2 /FET, while result for sig- χ^2 (*p-value*) = 1.000. Since *p-value* is more than 0.05, there is no significant correlation between both ATC and PTTD with ankle instability among participants with 3rd degree of severity of pes planus on the right foot in the present study.

Table 4.22: Correlation between Both ATC and PTTD with Ankle Instability among Participants with 3rd Degree of Severity of Pes Planus on Left Foot.

Presence of Both ATC and PTTD	Ankle Stability		χ^2/FET	df	*p-value*
	Normal	Instable			
	n (%)	n (%)			
Yes	4 (50.0%)	4 (50.0%)	-	-	.433
No	7 (33.3%)	14 (66.7%)			

Note: Fisher's Exact test was performed. n = number of participants; ATC = Achilles Tendon Contracture; PTTD = Posterior Tibial Tendon Dysfunction; df = degree of freedom. Level of significant at p > 0.05.

The correlation between ATC and ankle instability among participants with 3rd degree of severity of pes planus on the left foot is presented in **Table 4.22**. Among participants who were tested with the presence of both ATC and PTTD, the prevalence of ankle instability and prevalence of normal ankle stability was 50.0% (n=4) respectively. Among the participants who were tested without the presence of both ATC and PTTD, the prevalence of ankle instability was 66.7% (n=14) while the prevalence of normal ankle stability was 33.3% (n=7). Fisher's Exact test was performed as 50.0% of the cells had expected count less than 5. With this, there was no result obtained for χ^2/FET, while result for sig- χ^2 (*p-value*) = 1.000. Since *p-value* is more than 0.05, there is no significant correlation between both ATC and PTTD with ankle instability among participants with 3rd degree of severity of pes planus on the left foot in the present study.

4.11 Correlation between ATC and PTTD with Ankle Instability among Participants with 2nd Degree of Severity of Pes Planus

Table 4.23: Correlation between ATC and Ankle Instability among Participants with 2nd Degree of Severity of Pes Planus on Right Foot.

Presence of ATC	Ankle Stability		χ^2/FET	df	*p-value*
	Normal n (%)	Instable n (%)			
Yes	1 (25.0%)	3 (75.0%)	-	-	1.000
No	4 (40.0%)	6 (60.0%)			

Note: Fisher's Exact test was performed. n = number of participants; ATC = Achilles Tendon Contracture; df = degree of freedom. Level of significant at $p > 0.05$.

The correlation between ATC alone and ankle instability among participants with 2nd degree of severity of pes planus on the right foot is presented in **Table 4.23**. Among participants who were tested with the presence of ATC alone, the prevalence of ankle instability was 75.0% (n=3) while the prevalence of normal ankle stability was 25.0% (n=1) respectively. Among the participants who were tested without the presence of ATC alone, the prevalence of ankle instability was 60.0% (n=6) while the prevalence of normal ankle stability was 40.0% (n=4). Fisher's Exact test was performed as 75.0% of the cells had expected count less than 5. With this, there was no result obtained for χ^2 /FET, while result for sig- χ^2 (*p-value*) = 1.000. Since *p-value* is more than 0.05, there is no significant correlation between the ATC alone and ankle instability among participants with 2nd degree of severity of pes planus on the right foot in the present study.

Table 4.24: Correlation between ATC and Ankle Instability among Participants with 2nd Degree of Severity of Pes Planus on Left Foot.

Presence of ATC	Ankle Stability		χ^2/FET	df	*p-value*
	Normal	Instable			
	n (%)	n (%)			
Yes	6 (75.0%)	2 (25.0%)	-	-	.061
No	0 (0.0%)	3 (100.0%)			

Note: Fisher's Exact test was performed. n = number of participants; ATC = Achilles Tendon Contracture; df = degree of freedom. Level of significant at $p > 0.05$.

The correlation between ATC alone and ankle instability among participants with 2nd degree of severity of pes planus on the left foot is demonstrated in **Table 4.24.** Among participants who were tested with the presence of ATC alone, the prevalence of ankle instability was 25.0% (n=2) while the prevalence of normal ankle stability was 75.0% (n=6). Among the participants who were tested without the presence of ATC alone, the prevalence of ankle instability was 100.0% (n=3) while the prevalence of normal ankle stability was 0.0% (n=0) as none of these participants were tested with normal ankle instability. Fisher's Exact test was performed as 100.0% of the cells had expected count less than 5. With this, there was no result obtained for χ^2 /FET, while result for sig- χ^2 (*p-value*) = 0.061. Since *p-value* is more than 0.05, there is no significant correlation between the ATC alone and ankle instability among participants with 2nd degree of severity of pes planus on the left foot in the present study.

Table 4.25: Correlation between PTTD alone and Ankle Instability among Participants with 2nd Degree of Severity of Pes Planus on Right Foot.

Presence of PTTD	Ankle Stability		χ^2/FET	df	*p-value*
	Normal	Instable			
	n (%)	n (%)			
Yes	0 (0.0%)	1 (100.0%)	-	-	1.000
No	5 (38.5%)	8 (61.5%)			

Note: Fisher's Exact test was performed. n = number of participants; PTTD = Posterior Tibial Tendon Dysfunction; df = degree of freedom. Level of significant at $p > 0.05$.

The correlation between PTTD alone and ankle instability among participants with 2nd degree of severity of pes planus on the right foot is presented in **Table 4.25**. Among participants who were tested with the presence of PTTD alone, the prevalence of ankle instability was 100.0% (n=1) while the prevalence of normal ankle stability was 0.0% (n=0). Among the participants who were tested without the presence of PTTD alone, the prevalence of ankle instability was 61.5% (n=8) while the prevalence of normal ankle stability was 38.5% (n=5). Fisher's Exact test was performed as 75.0% of the cells had expected count less than 5. With this, there was no result obtained for χ^2 /FET, while result for sig- χ^2 (*p-value*) = 1.000. Since *p-value* is more than 0.05, there is no significant correlation between PTTD alone and ankle instability among participants with 2nd degree of severity of pes planus on the right foot in the present study.

Table 4.26: Correlation between PTTD and Ankle Instability among Participants with 2nd Degree of Severity of Pes Planus on Left Foot.

Presence of PTTD	Ankle Stability		χ^2/FET	df	*p-value*
	Normal n (%)	Instable n (%)			
Yes	0 (0.0%)	1 (100.0%)	-	-	.455
No	6 (60.0%)	4 (40.0%)			

Note: Fisher's Exact test was performed. n = number of participants; PTTD = Posterior Tibial Tendon Dysfunction; df = degree of freedom. Level of significant at $p > 0.05$.

The correlation between PTTD alone and ankle instability among participants with 2nd degree of severity of pes planus on the left foot is demonstrated in **Table 4.26**. Among participants who were tested with the presence of PTTD alone, the prevalence of ankle instability was 100.0% (n=1) while the prevalence of normal ankle stability was 0.0% (n=0) since there is none of the participants tested with normal ankle stability. Among the participants who were tested without the presence of PTTD alone, the prevalence of ankle instability was 40.0% (n=4) while the prevalence of normal ankle stability was 60.0% (n=6). Fisher's Exact test was performed as 75.0% of the cells had expected count less than 5. With this, there was no result obtained for χ^2 /FET, while result for sig- χ^2 (*p-value*) = 0.455. Since *p-value* is more than 0.05, there is no significant correlation between PTTD alone and ankle instability among participants with 2nd degree of severity of pes planus on the left foot in the present study.

Table 4.27: Correlation between Both ATC and PTTD with Ankle Instability among Participants with 3rd Degree of Severity of Pes Planus on Right Foot.

Presence of Both ATC and PTTD	Ankle Stability		χ^2/FET	df	*p-value*
	Normal n (%)	Instable n (%)			
Yes	3 (50.0%)	3 (50.0%)	-	-	.580
No	2 (25.0%)	6 (75.0%)			

Note: Fisher's Exact test was performed. n = number of participants; ATC = Achilles Tendon Contracture; PTTD = Posterior Tibial Tendon Dysfunction; df = degree of freedom. Level of significant at p > 0.05.

The correlation between both ATC and ankle instability among participants with 2nd degree of severity of pes planus on the right foot is presented in **Table 4.27**. Among participants who were tested with the presence of both ATC and PTTD, the prevalence of ankle instability and prevalence of normal ankle stability was 50.0% (n=3) respectively. Among the participants who were tested without the presence of both ATC and PTTD, the prevalence of ankle instability was 75.0% (n=6) while the prevalence of normal ankle stability was 25.0% (n=2). Fisher's Exact test was performed as 75.0% of the cells had expected count less than 5. With this, there was no result obtained for χ^2 /FET, while result for sig- χ^2 (*p-value*) = 0.580. Since *p-value* is more than 0.05, there is no significant correlation between both ATC and PTTD with ankle instability among participants with 2nd degree of severity of pes planus on the right foot in the present study.

Table 4.28: Correlation between Both ATC and PTTD with Ankle Instability among Participants with 3rd Degree of Severity of Pes Planus on Left Foot.

Presence of Both ATC and PTTD	Ankle Stability		χ^2/FET	df	*p-value*
	Normal n (%)	Instable n (%)			
Yes	0 (0.0%)	1 (100.0%)	-	-	.455
No	6 (60.0%)	4 (40.0%)			

Note: Fisher's Exact test was performed. n = number of participants; ATC = Achilles Tendon Contracture; PTTD = Posterior Tibial Tendon Dysfunction; df = degree of freedom. Level of significant at $p > 0.05$.

The correlation between both ATC and ankle instability among participants with 2nd degree of severity of pes planus on the left foot is presented in **Table 4.28**. Among participants who were tested with the presence of both ATC and PTTD, the prevalence of ankle instability was 100.0% (n=1) while the prevalence of normal ankle stability was 0.0% (n=0). Among the participants who were tested without the presence of both ATC and PTTD, the prevalence of ankle instability was 40.0% (n=4) while the prevalence of normal ankle stability was 60.0% (n=6). Fisher's Exact test was performed as 75.0% of the cells had expected count less than 5. With this, there was no result obtained for χ^2 /FET, while result for sig- χ^2 (*p-value*) = 0.455. Since *p-value* is more than 0.05, there is no significant correlation between both ATC and PTTD with ankle instability among participants with 2nd degree of severity of pes planus on the left foot in the present study.

4.12 Correlation between ATC and PTTD with Ankle Instability among Participants with 1st Degree of Severity of Pes Planus

Table 4.29: Correlation between ATC and Ankle Instability among Participants with 1st Degree of Severity of Pes Planus on Right Foot.

Presence of ATC	Ankle Stability		χ^2/FET	df	*p-value*
	Normal n (%)	Instable n (%)			
Yes	1 (20.0%)	4 (80.0%)	-	-	.615
No	5 (38.5%)	8 (61.5%)			

Note: Fisher's Exact test was performed. n = number of participants; ATC = Achilles Tendon Contracture; df = degree of freedom. Level of significant at p > 0.05.

The correlation between ATC alone and ankle instability among participants with 1st degree of severity of pes planus on the right foot is illustrated in **Table 4.29**. Among participants who were tested with the presence of ATC, the prevalence of ankle instability was 80.0% (n=4) while the prevalence of normal ankle stability was 20.0% (n=1) respectively. Among the participants who were tested without the presence of ATC alone, the prevalence of ankle instability was 61.5% (n=8) while the prevalence of normal ankle stability was 38.5% (n=5). Fisher's Exact test was performed as 75.0% of the cells had expected count less than 5. With this, there was no result obtained for χ^2 /FET, while result for sig- χ^2 (*p-value*) = 0.615. Since *p-value* is more than 0.05, there is no significant correlation between ATC alone and ankle instability among participants with 1st degree of severity of pes planus on the right foot in the present study.

Table 4.30: Correlation between Achilles Tendon Contracture and Ankle Instability among Participants with 1st Degree of Severity of Pes Planus on Left Foot.

Presence of ATC	Ankle Stability		χ^2/FET	df	*p-value*
	Normal	Instable			
	n (%)	n (%)			
Yes	3 (37.5%)	5 (62.5%)	-	-	.491
No	0 (0.0%)	4 (100.0%)			

Note: Fisher's Exact test was performed. n = number of participants; ATC = Achilles Tendon Contracture; df = degree of freedom. Level of significant at $p > 0.05$.

The correlation between ATC alone and ankle instability among participants with 1st degree of severity of pes planus on the left foot is demonstrated in **Table 4.30**. Among participants who were tested with the presence of ATC alone, the prevalence of ankle instability was 62.5% (n=5) while the prevalence of normal ankle stability was 3% (n=37.5). Among the participants who were tested without the presence of ATC alone, the prevalence of ankle instability was 100.0% (n=4) while the prevalence of normal ankle stability was 0.0% (n=0) as none of these participants were tested with normal ankle instability. Fisher's Exact test was performed as 75.0% of the cells had expected count less than 5. With this, there was no result obtained for χ^2 /FET, while result for sig- χ^2 (*p-value*) = 0.491. Since *p-value* is more than 0.05, there is no significant correlation between ATC alone and ankle instability among participants with 1st degree of severity of pes planus on the left foot in the present study.

Table 4.31: Correlation between PTTD and Ankle Instability among Participants with 1st Degree of Severity of Pes Planus on Right Foot.

Presence of PTTD	Ankle Stability		χ^2/FET	df	*p-value*
	Normal	Instable			
	n (%)	n (%)			
Yes	1 (33.3%)	2 (66.7%)	-	-	1.000
No	5 (33.3%)	10 (66.7%)			

Note: Fisher's Exact test was performed. n = number of participants; PTTD = Posterior Tibial Tendon Dysfunction; df = degree of freedom. Level of significant at $p > 0.05$.

The correlation between PTTD alone and ankle instability among participants with 1st degree of severity of pes planus on the right foot is presented in **Table 4.31**. Among participants who were tested with the presence of PTTD alone, the prevalence of ankle instability was 66.7% (n=2) while the prevalence of normal ankle stability was 33.3% (n=1) respectively. Among the participants who were tested without the presence of PTTD alone, the prevalence of ankle instability was 66.7% (n=10) while the prevalence of normal ankle stability was 33.3% (n=5). Fisher's Exact test was performed as 50.0% of the cells had expected count less than 5. With this, there was no result obtained for χ^2 /FET, while result for sig- χ^2 (*p-value*) = 1.000. Since *p-value* is more than 0.05, there is no significant correlation between PTTD alone and ankle instability among participants with 1st degree of severity of pes planus on the right foot in the present study.

Table 4.32: Correlation between PTTD and Ankle Instability among Participants with 1st Degree of Severity of Pes Planus on Left Foot.

Presence of PTTD	Ankle Stability		χ^2/FET	df	*p-value*
	Normal n (%)	Instable n (%)			
Yes	0 (0.0%)	2 (100.0%)	-	-	1.000
No	3 (30.7%)	3 (70.0%)			

Note: Fisher's Exact test was performed. n = number of participants; PTTD = Posterior Tibial Tendon Dysfunction; df = degree of freedom. Level of significant at p > 0.05.

The correlation between PTTD alone and ankle instability among participants with 1st degree of severity of pes planus on the left foot is demonstrated in **Table 4.32**. Among participants who were tested with the presence of PTTD alone, the prevalence of ankle instability was 100.0% (n=2) while the prevalence of normal ankle stability was 0.0% (n=0) since there is none of the participants tested with normal ankle stability. Among the participants who were tested without the presence of PTTD alone, the prevalence of ankle instability was 70.0% (n=7) while the prevalence of normal ankle stability was 30.0% (n=3). Fisher's Exact test was performed as 75.0% of the cells had expected count less than 5. With this, there was no result obtained for χ^2 /FET, while result for sig- χ^2 (*p-value*) = 1.000. Since *p-value* is more than 0.05, there is no significant correlation between PTTD alone and ankle instability among participants with 1st degree of severity of pes planus on the left foot in the present study.

Table 4.33: Correlation between Both ATC and PTTD with Ankle Instability among Participants with 1st Degree of Severity of Pes Planus on Right Foot.

Presence of Both ATC and PTTD	Ankle Stability		χ^2/FET	df	*p-value*
	Normal n (%)	Instable n (%)			
Yes	2 (40.0%)	3 (60.0%)	-	-	1.000
No	4 (30.8%)	9 (69.2%)			

Note: Fisher's Exact test was performed. n = number of participants; ATC = Achilles Tendon Contracture; PTTD = Posterior Tibial Tendon Dysfunction; df = degree of freedom. Level of significant at p > 0.05.

The correlation between both ATC and ankle instability among participants with 1st degree of severity of pes planus on the right foot is presented in **Table 4.33**. Among participants who were tested with the presence of both ATC and PTTD, the prevalence of ankle instability was 60.0% (n=3) while the prevalence of normal ankle stability was 40.0% (n=2). Among the participants who were tested without the presence of both ATC and PTTD, the prevalence of ankle instability was 69.2% (n=9) while the prevalence of normal ankle stability was 30.8% (n=4). Fisher's Exact test was performed as 75.0% of the cells had expected count less than 5. With this, there was no result obtained for χ^2 /FET, while result for sig- χ^2 (*p-value*) = 1.000. Since *p-value* is more than 0.05, there is no significant correlation between both ATC and PTTD with ankle instability among participants with 1st degree of severity of pes planus on the right foot in the present study.

Table 4.34: Correlation between Both ATC and PTTD with Ankle Instability among Participants with 1st Degree of Severity of Pes Planus on Left Foot.

Presence of Both ATC and PTTD	Ankle Stability		χ^2/FET	df	*p-value*
	Normal	Instable			
	n (%)	n (%)			
Yes	0 (0.0%)	1 (100.0%)	-	-	1.000
No	3 (27.3%)	8 (72.7%)			

Note: Fisher's Exact test was performed. n = number of participants; ATC = Achilles Tendon Contracture; PTTD = Posterior Tibial Tendon Dysfunction; df = degree of freedom. Level of significant at p > 0.05.

The correlation between both ATC and ankle instability among participants with 1st degree of severity of pes planus on the left foot is presented in **Table 4.34**. Among participants who were tested with the presence of both ATC and PTTD, the prevalence of ankle instability was 100.0% (n=1) while the prevalence of normal ankle stability was 0.0% (n=0). Among the participants who were tested without the presence of both ATC and PTTD, the prevalence of ankle instability was 72.7% (n=8) while the prevalence of normal ankle stability was 27.3% (n=3). Fisher's Exact test was performed as 75.0% of the cells had expected count less than 5. With this, there was no result obtained for χ^2 /FET, while result for sig- χ^2 (*p-value*) = 1.000. Since *p-value* is more than 0.05, there is no significant correlation between both ATC and PTTD with ankle instability among participants with 1st degree of severity of pes planus on the left foot in the present study.

CHAPTER 5

DISCUSSION

5.1 Chapter Overview

In this section, the findings of ATC and PTTD on ankle instability among young adults with pes planus will be discussed. In additions, the significance, limitations and recommendations for the present study will be discussed in this section as well.

5.2 Demographic Findings

In the present study, the data of a total of 57 young adults were analysed. Demographic data regarding distribution of participants in terms of BMI category, awareness for the presence of pes planus, activity level, sports involvement, frequency of sport participation, nature of pes planus, leg dominance, degree of severity, prevalence of ATC or PTTD and ankle instability as presented in Chapter 4 will be further discussed in this chapter.

By comparing within the gender, it is found that majority of the young adults with pes planus are male with a prevalence of 54.4% compare to female with a prevalence of 45.6%. Similar findings were showed by Igbinedion et al. (2022) and Khadanga & Kumar (2022) that were conducted among young adults as well. This may due to the one-year delayed development of the rearfoot valgus in males compare to the females (Pfeiffer et al., 2006). As a result, larger rearfoot valgus angle are exhibited by the males, which resulted in the increasing risk of pes planus development. Therefore, these two factors may be the main causal for the greater prevalence of pes planus in male young adults than in female young adults.

5.2.1 BMI Category Distribution

Other than gender, the young adults with pes planus in this present study is further grouped according to their BMI category. Comparing between young adults with normal BMI category and overweight and obese category, it was found that normal BMI category shows greater percentage compare to young adults categorized in overweight and obese by 64.9% to 35.1%. This result is contradictory to the findings by Stolzman et al. (2015), Pourghasem et al. (2016) and Shariff et al. (2017), where their result shown greater prevalence of pes planus among individuals categorized as overweight and obese. Participants recruited in this study were mostly categorized in normal BMI, thus causing unequal distribution of participants according to BMI category. This may be due to the target population in this study were young adults, who are within the most productive years of their life, tends to have greater participation in physical activity. From results of Suryadinata et al. (2020) shows that age is associated with physical activity level of the adults. This is explained by the result of this study, which shows that 85.7% of the young adults had sports involvement. This is due to the fact that physical activity participation is negatively associated with BMI index (Cárdenas Fuentes et al., 2018). Therefore, the increase of physical activity participation is a main factor for majority of the young adults found categorized as normal BMI rather than overweight and obese.

5.2.2 Physical Activity Distribution

By comparing the result of the activity level of the young adults, it is found that only 12.3% of the young adults had reported with none physical activity in a week. On the flip side, 87.6% of the young adults reported to have frequency of sport participation of at least once in a week. From our research, this higher physical activity level showed by the young adults did not support the findings from Furgał & Adamczyk (2008) and Truszczyńska-Baszak et al. (2017). Based on the study from Furgał & Adamczyk (2008), it is observed that individuals with pes planus tend to restrict themselves from physical activity. In which 62.9% and 39.5% of the girls and boys with pes planus are those who refuse to take part in any of the physical activities. This phenomenon may be associated with the presence of ankle instability among these individual, resulting in the development of fear of falls. This theory is supported with findings from Jefferis et al. (2014) where fear of fall is found negatively associated with step count and physical activity level. However, this phenomenon does not seem to be the same in our study. In our study, young adults were observed to have higher prevalence of physical activity. This might be associated to the low awareness among these young adults. As reported, 71.9% of the young adults are unaware for this defect of the foot arch among them. This may be due to the asymptomatic nature of this deformity (Raj et al., 2022). Thus, they may not notice that the ankle instability is the result of the pes planus, instead, they might treat it as a sign indicating that their muscles are not strong enough. Hence, they engaged in more sports and physical activity in order to strengthen themselves from the poor stability that they experienced.

5.2.3 Nature of Pes Planus Distribution

In this present study, it is shown that young adults with pes planus exist as bilaterally with higher prevalence than unilaterally, with a percentage of 78.9% to 21.1%. This result is in line with the findings from Reddy & Kishve (2021), where bilateral pes planus was found with a higher prevalence of 11.6%, while the unilateral pes planus was found with a prevalence of 3% among young adults.

5.2.4 Leg Dominance Distribution

From the result obtained in this present study, it is found that 53 out of 57 of all young adults had pes planus that occurred over the dominant leg. Further looking into this, 11.8% of the unilateral pes planus young adults and 79.4% of the bilateral pes planus young adults had pes planus occurring over their right dominant leg. While 17.4% of the unilateral pes planus young adults and 78.3% of the bilateral pes planus young adults are found with pes planus occurring over their left dominant leg. In other words, only 4 young adults are not tested with pes planus developed on their dominant leg. This finding is found similar to the result produced by Talati et al. (2018), where they found that there is significant correlation between pes planus and leg dominance among young adults. This is due the fact that there is an increased risk of dystrophy on the dominant side, the preference side on performing motor tasks (Talati et al., 2018). The increasing usage in performing motor task on the dominant leg will increase pressure loading on the foot structure. Therefore, the increasing stress on the foot structure leads to dysfunction occurring over the stabilizer of the foot arch, causing the defect in this arch to occur.

5.2.5 Degree of Severity Distribution

In this present study, it is found that there is higher prevalence of 3rd degree of severity on the left foot compare to other degree of severity with percentage of 50.9%. While on the right foot, the 3rd degree of severity shared the same percentage as 1st degree of severity, which both the severity level obtained a percentage of 31.6%. This finding is similar to the finding of Zhang et al. (2022), where 45 out of 75 participants demonstrated with higher prevalence of pes planus in 3rd degree of severity. The greater prevalence in 3rd degree of severity shown in this study may be resulting from the BMI index of this group of young adults. In such, results show that the young adults from 3rd degree of severity has greatest mean value of BMI index compare to the other 2 groups, which are 24.88 ± 4.896 kgm^{-2} found for right foot and 23.99 ± 5.863 kgm^{-2} for left foot. Additionally, the left foot, the non-dominant side of majority of the young adults in this study were found to have greater severity level than the right foot. This phenomenon may be the result of more frequent occurrence of ankle injury over the dominant of the leg. In which, study by Ekstrand & Gillquist (1983) found that the male soccer player had more significant ankle injuries occurring over the dominant side, with 92% injuries reported on the dominant side. Thus, with the increasing incidence of ankle injury on the dominant side, the individual will tend to shift their weight more towards the non-dominant side during standing. Thus, more pressure put on the non-dominant side, the left foot. The increasing weight pressure shifted towards the left foot further worsening on the medial longitudinal arch that is already flatten, causes progressive flattening on the arch. Therefore, the left foot of young adults will have higher severity level than the right foot.

5.2.6 Prevalence of ATC and PTTD among Young Adults

Majority of the participants were found with presence of both ATC and PTTD instead of the two musculoskeletal conditions alone. By comparing the presence of ATC and PTTD, it shows that 42.1% of the young adults were tested positive for both ATC and PTTD. Moreover, 33.3% of the prevalence for ATC only and 17.5% of the prevalence for PTTD only were observed among the young adults. Up to date, there is lack of study which discussed the prevalence of ATC and PTTD occurring simultaneously among young adults with pes planus.

This findings for the total prevalence of ATC of 75.4% is in line with the findings from Reimers et al. (1995). In such, Reimers et al. (1995) stated that more than half of the adolescences were screened for the presence of ATC, showing prevalence of 77%. This may be largely associated to the poor stretching technique practiced by the participants after their sport session. The above theory is supported with findings from D. Y. Park et al., (2011), where they suggested that prolong and more intensive stretching and warm-up routine should be introduced to the recreational athlete in order to cause any changes of biomechanical properties. This is due to the findings from D. Y. Park et al. (2011), where either stretching or warm-up implemented in the study did not showed statistically difference in the biomechanical properties of Achilles tendon prior and after the study.

Moreover, the total prevalence for PTTD was 59.6% and PTTD alone was 17.5%. This finding was similar to the findings of Kohls-Gatzoulis et al. (2009) and Knapp & Constant (2022) but opposed to Jahss (1991). The prevalence found in the present study shown similar findings to Kohls-Gatzoulis et al. (2009) and Knapp & Constant (2022) where this study found the prevalence of PTTD among the populations and specifically on pes planus population was approximately 10% and 13.51%. However, findings from the Jahss (1991) does not tally with the findings in the present study where they stated that the prevalence of PTTD for pes planus individuals were 100.0%. This may be associated to nearly more than half of the young adults in this study were having physical activity for at least once per week. To support this statement, reviewed conducted by Ross et al. (2018) concluded that strengthening exercises, especially eccentric exercises practiced by the participants with PTTD shown improvements in several aspects, such in pain management and functional activities. Therefore, physical activity may be the cause for the low prevalence of PTTD among young adults with pes planus.

5.2.7 Prevalence of Ankle Instability among Young Adults

From the findings, 64.9% of the young adults demonstrated a positive test during the Y Balance test, indicating the presence of ankle instability. The high prevalence of ankle instability was found on 3rd degree of severity on the left foot as well, with percentage of 62.1%. This finding is similar to those of Tahmasebi et al. (2015), Sung et al. (2017), Dabholkar & Agarwal (2020), Koshino et al. (2020), Adegoke et al. (2021) and Marouvo et al. (2021). From study of Dabholkar & Agarwal (2020), it is reported that 43% of the participants with pes planus experienced problem on stability, which is almost similar with our findings. The high prevalence of ankle instability may be due to several causes, however, in this study we suggested that it is greatly associated to the complication of pes planus, along with the additional existence of ATC and PTTD. This is mainly because the defect in the foot arch had cause the instability over the ankle. Findings from Tahmasebi et al. (2015), Sung et al. (2017), Koshino et al. (2020) and Marouvo et al. (2021) seems to rectify with this statement. From their studies, it is found that there is a significant association between pes planus with the poor stability of the affected individuals. These individuals tend to exhibit poorer stability than the others during the study. In which, Koshino et al. (2020) found that pes planus individuals tend to have significant displacement of the center of pressure, causing the poor static stability persist within these individuals.

5.3 Correlation between ATC Alone with Ankle Instability

In the present study, there is no significant correlation found between ATC along with ankle instability among young adults with pes planus. In specific, the division of young adults based on unilateral pes planus, bilateral pes planus, leg dominance and all 3 degrees of severity (1^{st}, 2^{nd} and 3^{rd}) showed no significant correlation between ATC alone with ankle instability. This finding is contradictory to the results from Endo & Sakamoto (2014), where they found that their participants showed significant reduction of reaching distance during SEBT in anterior, medial and lateral direction. This may be due to the fact that the participants recruited in Endo & Sakamot (2014) are elite baseball player who represent the high school, while the participants from our study were mostly recreational athlete from various sports.

Due to the profession, the elite baseball players have greater risk of frequent injury occurrence. This is shown through study conducted by Okoroha et al. (2019) and Lucasti et al. (2020), where the professional elite baseball players exhibit a recurrent hamstring injury rate of up to 16.3% and a total of 4756 ankle injuries occurred in between 2011 to 2016, which some of them requires surgical management. Thus, the increase frequency of severe injuries, especially over the ankle will cause further compromise of the ankle instability of the elite baseball players. This is supported with results from McGuine et al. (2000), where individuals with poor stability were found to have previous history of ankle injury by seven times more. To further add on, study by Lucasti et al., 2020) had address that 32% to 74% of the individuals with past history of ankle injuries are more likely to suffer from ankle instability. Therefore, this explained that the study on baseball players with ATC will show more significant result on ankle instability than the young adults from our study.

In addition, from the result it is shown that 87.7% of the young adults reported with sport participations of at least once a week. This sport participation by the young adults may be the cause for the result between the ATC and ankle instability to be not significant. The increasing physical activity level will induce working of the other stability muscles, such as core stability. This will eventually overcome the shortness of ankle instability of these individuals to maintain their balance. This statement is based on findings from Kapdule et al. (2019), where participants in the study demonstrates significant association between core stability and physical activity, where participants with higher level of physical activity demonstrates greater stability of the core. Furthermore, study by Dastmanesh et al. (n.d.) founds that participants with ankle instability after core stabilization training will have a positive effect on their postural control. Therefore, it can be said that the increase of core stability through increase in physical activity level will cause a positive effect in stabilization even though the person had ankle instability.

5.4 Correlation between PTTD Alone with Ankle Instability

Despite analysing the data based on unilateral pes planus, bilateral pes planus, leg dominance and all 3 degrees of severity (1^{st}, 2^{nd} and 3^{rd}), it is found that there is no significant correlation in between PTTD alone on ankle instability among young adults with pes planus. The findings that were not significant for PTTD with ankle instability among young adults with pes planus does not correlated to the findings from Kulig et al. (2015) and Wang et al. (2022). The study from Kulig et al. (2015) finds that participants in their research had significant lower success rate in performing unipedal standing balance test. The results differ may be due to the difference in target participants. In the present study, both genders of young adults were recruited, whereas study in Kulig et al. (2015) only recruited female participants from the age group of 40 to 66 years.

The age difference across the two studies may resulting in the difference of significant level on the association between PTTD and ankle instability. This statement is supported through finding from Svoboda et al. (2019) showed that aging caused a significant effect on the ankle muscle strength and postural control. The poorer stability in ankle in the older age group is highly associated to degeneration of the neuromuscular system. It is shown that there is a declination of the peak torque in the older adults, following by a reduction of approximately 30% in muscle strength of the older adults (Spink et al., 2010; Svoboda et al., 2019). Therefore, significantly poorer ankle instability in study from Kulig et al. (2015) may be due to aging factors as well. As the participants in our study are mainly young adults that more than half of them had weekly sport participation. The frequent sports participant is beneficial in improving the stability of the young adults. This is due to the fact that the physical activity recruit other muscles of stability as well, continuous recruitment of these muscles will help to overcome the shortness in ankle stability in maintaining the balance of the young adults (Dastmanesh et al., n.d.).

Despite that the result shows no significant correlation between PTTD on ankle instability among young adults with pes planus. However, the result shows that the PTTD on young adults with 3rd degree of severity on the left foot have a prevalence of 66.7% for ankle instability. This high level of prevalence ankle instability may be due to the severity of the pes planus. The increasing severity of the pes planus is associated to the increasing symptoms and complications to the individuals. This is found with study from (Zhang et al., 2022) presents that the increasing severity of pes planus is associated with increasing severity of knee degeneration, such as knee stiffness and knee pain, increasing risk of knee osteoarthritis (OA). The increasing knee pathology will indirectly cause an increases risk of stability as well. The participants with knee OA had exhibit significant decrease in articular movement in the subtalar and ankle joint. The alteration in these joints lead to biomechanical disadvantage which influenced on the ankle stability secondary to structural changes in the knee joint (Hubbard et al., 2010).

5.5 Correlation between Both ATC and PTTD with Ankle Instability

In the present study, the data collected showed no significant correlation in between both ATC and PTTD on ankle instability among young adults. The significance of the correlation is not influenced by unilateral pes planus, bilateral pes planus, leg dominance and all 3 degrees of severity (1st, 2nd and 3rd). Up to date, there is no research conducted regarding the effect of both ATC and PTTD on the stability of the ankle. Apart from the significance, the prevalence of ankle instability among pes planus young adults with both ATC and PTTD were comparative lesser than the prevalence of ankle instability among pes planus young adults with either ATC or PTTD alone, where 54.2% compare to 68.4% and 90.0%. The result for no significance and low prevalence between both ATC and PTTD with ankle instability might be associated to the physical activity level, which 87.7% of the young adults had weekly sport participation for at least once. The participation in sport activity is beneficial in strengthening the stability and overcome the effect brought by ATC and PTTD. This is supported with findings from Kapdule et al. (2019), where significant association between core stability and physical activity were found on the participants, where participants with higher level of physical activity demonstrates greater stability of the core. The increase strength in core stability muscle will helps in overcoming the deficit in ankle stability, thus, maintaining the stability of the individuals.

Although in this study, it is found that 64.9% of the young adults experienced ankle instability. However, the results show that there is no significant correlation between both ATC and PTTD on ankle instability among the young adults with pes planus. The high prevalence of ankle instability may be due to other risk factors that is not investigated in this study, such as ligament laxity. Since all young adults in this study experienced ankle sprains previously, joint and ligament laxity should be suspected persist within these young adults. Hertel et al. (1999) examined 20 participants and found that participants who sustained injury previously show significant greater talar tilt angle and anterior talofibular laxity compare to participants without history of injury. Apart from the muscles, the ligaments play a vital role in maintaining the stability of the ankle. Following by the rupture over the ligaments resulted from the ankle injury, the ligaments is no longer intact and loses its ability to hold on the ankle joint. Therefore, causes an increase of anterior displacement occurring over the ankle joint. This is supported with findings from Hubbard (2008), where it is examined that participants with chronic ankle instability present significantly greater anterior displacement and inversion rotation compared to the participants without chronic ankle instability, which were in controlled by the talofibular ligament and calcaneofibular ligament. This shows that recurrent ankle sprain that causes damage on the ligament structures over the ankle joint will increases the risk of ankle instability.

Apart from that, the age of the young adults included in this study might be one of the risk factors contributing to the higher prevalence of ankle instability. Based on study from Pourkazemi et al. (2018), it is observed that participants at the age 24 years old and below are at higher risk for encountering recurrent ankle sprains. In which, the participants of age 24 years old and below are found to have 8 times greater risk in encountering recurrent sprain than the older participants. The young adults included in our study are all below the age of 24 years, with a mean age of 20.46 ± 1.310 years. Hence, it is suspected that the higher prevalence of ankle instability may be due to the age factor as well. The greater risk of these young adults may be the result of their negligence towards proper injury management. Young adults often treat ankle sprains as a small injury and neglect to receive proper management and rehabilitation for the sprained ankle. With proper management of the ankle sprain, such as strengthening exercises and balancing exercises with the use of wobble board is effective in preventing the incidence of recurrent sprains (van der Wees et al., 2006). Therefore, participants who did not received an appropriate treatment and management following to an ankle sprain will resulting in greater risk of recurrent ankle sprains to occur, resulting in the development of ankle instability.

5.6 Limitations of Study

Despite the interesting findings from the research, several limitations were observed in the current study. First of all, the study was only conducted among young adults from UTAR, thus the findings might not be able to generalized to all young adults. Furthermore, the sample size for this study is too small. Despite that the researcher had successfully recruited a total number of 177 participants and screened the prevalence of pes planus among young adults are 58.76% (n=104). However, only findings from 57 participants were included for the analysis, which is far from the expected sample size of 401. This is due to the pre-set inclusion and exclusion criteria that filtered out the participants that were not eligible to be included as part of this study. Thus, only 57 participants were included from the 104 participants screened with pes planus. Another limitation in this study was the duration of research conduction. Due to time constraint, it had also limited the number of participants that the researchers can approach and recruit for this study. This small sample size may create an impact on the validity of the result, causing the result of this study to be not significant. Apart from that, the accuracy of pes planus screening with the use of footprints and CSI value is questionable. Although it is reported that CSI had a sensitivity and specificity that are found to be high as 87.6% and 88.4%, some minor alteration may not be suitable with the use of this standard (Chen et al., 2011). Researchers had encounter problems where the participants foot arch seems disappear upon observation. However, from the footprint and CSI shows that the participants had normal foot arch instead of pes planus. Apart from that, it is observed that some of the footprint consist of a “hole” in between the medial border of the foot and the arch, which appears an empty space in between the foot. Footprints in such are unable to be measured with the use of the CSI, thus all these footprints are excluded from this study and is classified as invalid data.

5.7 Recommendations for Future Study

To recruit and generalize the findings to a larger population, future research is suggested to increase the target population by including young adults from other universities in Malaysia as well. By doing so, there will be a more comprehensive view on the correlation between Achilles tendon contracture and PTTD on ankle instability among the young adults with pes planus in Malaysia. Additionally, it is advised for future study to recruit pes planus young adults with or without previous history of ankle sprains. As observed from our research, only 54.8% of these young adults had history of ankle sprains or injuries of more than a month. Thus, it is believed that by including pes planus participants without previous history of ankle sprain will increases the number of participants, producing a more reliable results that can be generalized to the public. Furthermore, it is recommended to increase the duration for commencement of research. This short period of time allocated is insufficient and had caused a lot of restriction for participants recruitment where the period for data collection is only two to three weeks. It is believed that the quality of the research will be improved if a longer duration is provided to the students. Lastly, future research should consider implementations of other method for pes planus screening. This is to eliminate the error as mentioned above while ensuring the accuracy of the data can be enhanced. Therefore, it is recommended to use more reliable and feasible screening tools such as foot pressure scanner for pes planus screening.

CHAPTER 6

CONCLUSION

In conclusion, young adults in UTAR showed a prevalence for pes planus with a percentage of 72.15% (n=57) out of 79 young adults recruited in this study. It is found that the left pes planus foots are having higher severity, where 50.9% of the left foot were classified as 3^{rd} degree of severity. Apart from that, it is shown that prevalence of ATC alone was 33.3%, PTTD alone was 17.5%, both ATC and PTTD was 42.1% and ankle instability was 64.9%. This showed that young adults with pes planus are having greater tendency to develop both ATC and PTTD. Although there is high prevalence shown on the prevalence of ankle instability among the young adults with pes planus. However, there is no significant correlation found in between ATC alone with ankle instability, PTTD alone with ankle instability and both ATC and PTTD with ankle instability from this present study. The no significant findings of the correlations did not vary among young adults with pes planus in respect to unilateral pes planus, bilateral pes planus, leg dominance and all 3 degrees of severity (1^{st}, 2^{nd} and 3^{rd}).

Apart from the findings mentioned above, some interesting findings were noticed as well from this study. Among all 177 participants, it is noticed that only 1.7% of the right and left foot of the participants were classified as normal foot arch respectively. The low percentage of normal foot arch participants found within this study is worrisome and a new arising problem that we need to further look into in the future. In addition, among young adults with pes planus, only

28.1% of the young adults reported that they are aware regarding the presence of pes planus, while the remaining 71.9% of the participants are unaware for the presence of pes planus among them. It is important to educate and spread the general awareness and knowledge of pes planus among the public regarding their foot health, as early diagnosis can prevent the further progression of this deformity, correcting this foot arch back to near normal as soon as possible before other complications that are devastating to the health of the individual had occur.

REFERENCE

Abousayed, M. M., Alley, M. C., Shakked, R., & Rosenbaum, A. J. (2017). Adult-Acquired Flatfoot Deformity. *JBJS Reviews*, *5*(8), e7–e7.

Adegoke, B. O., Alumona, C. J., Adeyemo, A. A., & Adeyinka, A. O. (2021). Flatfoot and balance performance among junior secondary school students in Ibadan, Nigeria. *New Zealand Journal of Physiotherapy*, *49*(2), 82–88.

Aenumulapalli, A., Kulkarni, M. M., & Gandotra, A. R. (2017). Prevalence of Flexible Flat Foot in Adults: A Cross-sectional Study. *Journal of Clinical and Diagnostic Research : JCDR*, *11*(6), AC17–AC20.

Alakija, W. (1979). Prevalence of Flat Foot in School Children in Benin City, Nigeria. *Tropical Doctor*, *9*(4), 192–194.

Al-Khudairi, N., Reid, C. E. L., Witham, F., & Chandrasekaran, K. (2019). Foot deformities – a pictorial review. *Clinical Radiology*, *74*, e4.

Almutairi, A. F., BaniMustafa, A., bin Saidan, T., Alhizam, S., & Salam, M. (2021). The Prevalence and Factors Associated with Low Back Pain Among People with Flat Feet. *International Journal of General Medicine*, *14*, 3677–3685.

Alsuhaymi, A., Almohammadi, F., Alharbi, O., Alawfi, A., Olfat, M., Alhazmi, O., & Khoshhal, K. (2019). Flatfoot among school-age children in Almadinah Almunawwarah: Prevalence and risk factors. *Journal of Musculoskeletal Surgery and Research*, *3*(2), 204.

Amis, J. (2016). The Split Second Effect: The Mechanism of How Equinus Can Damage the Human Foot and Ankle. *Frontiers in Surgery*, *3*.

Andrade, C. (2021). The Inconvenient Truth About Convenience and Purposive Samples. *Indian Journal of Psychological Medicine*, *43*(1), 86–88.

Atbaşı, Z., Erdem, Y., Kose, O., Demiralp, B., Ilkbahar, S., & Tekin, H. O. (2020). Relationship Between Hallux Valgus and Pes Planus: Real or Fiction? *The Journal of Foot and Ankle Surgery*, *59*(3), 513–517.

Bell, D. R., Guskiewicz, K. M., Clark, M. A., & Padua, D. A. (2011). Systematic review of the balance error scoring system. *Sports Health*, *3*(3), 287–295.

Benedetti, M. G., Ceccarelli, F., Berti, L., Luciani, D., Catani, F., Boschi, M., & Giannini, S. (2011). Diagnosis of Flexible Flatfoot in Children: A Systematic Clinical Approach. *Orthopedics*, *34*(2).

Berlet, G. C., Ebaugh, M. P., Talavera, F., & Panchbhavi, V. K. (2021, April 28). *Pes Planus (Flatfoot) Clinical Presentation: History, Physical*

Examination. Emedicine.Medscape.Com. https://emedicine.medscape.com/article/1236652-clinical#b2

Bhattacharjee, N., & Goswami, M. (2017). Footprint analysis and prevalence of flatfoot: A study among the children of South 24 Parganas, West Bengal, India. *Anthropological Review*, *80*(4), 369–380.

Bhoir, T., Anap, D. B., & Diwate, A. (2014). Prevalence of flat foot among 18-25 years old physiotherapy students: cross sectional study. *Indian Journal of Basic and Applied Medical Research*, 272–278.

Bouchard, M., & Mosca, V. S. (2014). Flatfoot Deformity in Children and Adolescents. *Journal of the American Academy of Orthopaedic Surgeons*, *22*(10), 623–632.

Bubra, P. S., Keighley, G., Rateesh, S., & Carmody, D. (2015). Posterior tibial tendon dysfunction: an overlooked cause of foot deformity. *Journal of Family Medicine and Primary Care*, *4*(1), 26–29.

Cárdenas Fuentes, G., Bawaked, R. A., Martínez González, M. Á., Corella, D., Subirana Cachinero, I., Salas-Salvadó, J., Estruch, R., Serra-Majem, L., Ros, E., Lapetra Peralta, J., Fiol, M., Rekondo, J., Gómez-Gracia, E., Tur Marí, J. A., Pinto Sala, X., Babio, N., Ortega, C., Martínez, J. A., & Schröder, H. (2018). Association of physical activity with body mass index, waist circumference and incidence of obesity in older adults. *European Journal of Public Health*, *28*(5), 944–950.

Chen, K.-C., Yeh, C.-J., Kuo, J.-F., Hsieh, C.-L., Yang, S.-F., & Wang, C.-H. (2011). Footprint analysis of flatfoot in preschool-aged children. *European Journal of Pediatrics*, *170*(5), 611–617.

Cheung, J. T.-M., Zhang, M., & An, K.-N. (2006). Effect of Achilles tendon loading on plantar fascia tension in the standing foot. *Clinical Biomechanics*, *21*(2), 194–203.

Cooke, M. W. (2003). A survey of current consultant practice of treatment of severe ankle sprains in emergency departments in the United Kingdom. *Emergency Medicine Journal*, *20*(6), 505–507.

Dabholkar, T., & Agarwal, A. (2020). Quality of Life in Adult Population with Flat Feet. In *International Journal of Health Sciences and Research (www.ijhsr.org)* (Vol. 10, Issue 2).

Dastmanesh, S., Sadroaldin Shojaedin, S., & Eskandari, E. (n.d.). The Effects of Core Stabilization Training on Postural Control of subjects with Chronic Ankle Instability. *Scholars Research Library Annals of Biological Research*, *2012*(8), 3926–3930.

Donatelli, R. (1985). Normal Biomechanics of the Foot and Ankle. *Journal of Orthopaedic & Sports Physical Therapy*, *7*(3), 91–95.

Ekstrand, J., & Gillquist, J. (1983). Soccer injuries and their mechanisms. *Medicine & Science in Sports & Exercise, 15*(3), 267.

Elwood, M. (2007). *Critical appraisal of epidemiological studies and clinical studies* (3rd ed.). Oxford: Oxford University Press.

Endo, Y., & Sakamoto, M. (2014). Relationship between Lower Extremity Tightness and Star Excursion Balance Test Performance in Junior High School Baseball Players. *Journal of Physical Therapy Science*, *26*(5), 661–663.

Fong, D. T.-P., Hong, Y., Chan, L.-K., Yung, P. S.-H., & Chan, K.-M. (2007). A Systematic Review on Ankle Injury and Ankle Sprain in Sports. *Sports Medicine*, *37*(1), 73–94.

Furgał, W., & Adamczyk, A. (2008). Foot arch formation in children depending on physical activity level. *Pol. J. Sports Med, 24*, 311–317.

Gonzalez-Martin, C., Pita-Fernandez, S., & Pertega-Diaz, S. (2018). Quality of Life and Functionality in Patients with Flatfoot. In *Update in Management of Foot and Ankle Disorders*. InTech.

Gonzalez-Martin, C., Pita-Fernandez, S., Seoane-Pillado, T., Lopez-Calviño, B., Pertega-Diaz, S., & Gil-Guillen, V. (2017). Variability between Clarke's angle and Chippaux-Smirak index for the diagnosis of flat feet. *Colombia Medica (Cali, Colombia)*, *48*(1), 25–31.

Gourdine-Shaw, M. C., Lamm, B. M., Herzenberg, J. E., & Bhave, A. (2010). Equinus Deformity in the Pediatric Patient: Causes, Evaluation, and Management. *Clinics in Podiatric Medicine and Surgery*, *27*(1), 25–42.

Gribble, P. A., Delahunt, E., Bleakley, C., Caulfield, B., Docherty, C., Fourchet, F., Fong, D., Hertel, J., Hiller, C., Kaminski, T., McKeon, P., Refshauge, K., van der Wees, P., Vicenzino, B., & Wikstrom, E. (2013). Selection Criteria for Patients With Chronic Ankle Instability in Controlled Research: A Position Statement of the International Ankle Consortium. *Journal of Orthopaedic & Sports Physical Therapy*, *43*(8), 585–591.

Han, Y., Duan, D., Zhao, K., Wang, X., Ouyang, L., & Liu, G. (2017). Investigation of the Relationship Between Flatfoot and Patellar Subluxation in Adolescents. *Journal of Foot and Ankle Surgery*, *56*(1), 15–18.

Hegazy, F., Aboelnasr, E., Abdel-Aziem, A., Hassan, A., & Kim, I.-J. (2022). Validity and Diagnostic Accuracy of the Clarke's Angle in Determining Pediatric Flexible Flatfoot Using Radiographic Findings as a Criterion Standard Measure: A Cross-sectional Study. *Journal of the American Podiatric Medical Association, 112*(1).

Hegazy, F., Aboelnasr, E., Abuzaid, M., Kim, I.-J., & Salem, Y. (2021). Comparing Validity and Diagnostic Accuracy of Clarke's Angle and Foot Posture Index-6 to Determine Flexible Flatfoot in Adolescents: A Cross-

Sectional Investigation. *Journal of Multidisciplinary Healthcare*, *Volume 14*, 2705–2717.

Herchenröder, M., Wilfling, D., & Steinhäuser, J. (2021). Evidence for foot orthoses for adults with flatfoot: a systematic review. *Journal of Foot and Ankle Research*, *14*(1), 57.

Hertel, J., Denegar, C. R., Monroe, M. M., & Stokes, W. L. (1999). Talocrural and subtalar joint instability after lateral ankle sprain. *Medicine & Science in Sports & Exercise*, *31*(11), 1501.

Hill, R. S. (1995). Ankle equinus. Prevalence and linkage to common foot pathology. *Journal of the American Podiatric Medical Association*, *85*(6), 295–300.

Hølmer, P., Søndergaard, L., Konradsen, L., Nielsen, P. T., & Jørgensen, L. N. (1994). Epidemiology of Sprains in the Lateral Ankle and Foot. *Foot & Ankle International*, *15*(2), 72–74.

Hubbard, T. J. (2008). Ligament Laxity Following Inversion Injury with and without Chronic Ankle Instability. *Foot & Ankle International*, *29*(3), 305–311.

Hubbard, T. J., Hicks-Little, C., & Cordova, M. (2010). Changes in Ankle Mechanical Stability in Those With Knee Osteoarthritis. *Archives of Physical Medicine and Rehabilitation*, *91*(1), 73–77.

Igbinedion, E. N., Jewo, A. O., Okoro, S., & Obianke, J. C. (2022). Prevalence of Flat Foot using Plantar Arch Index among Young Adults of Delta State, Nigeria. In *Malaysian Journal of Medicine and Health Sciences* (Vol. 18, Issue 3).

Jahss, M. H. (1991). In: Disorders of the Foot and Ankle. *2nd Ed. Philadelphia: WB Saunders*, 1461–1513.

Jefferis, B. J., Iliffe, S., Kendrick, D., Kerse, N., Trost, S., Lennon, L. T., Ash, S., Sartini, C., Morris, R. W., Wannamethee, S. G., & Whincup, P. H. (2014). How are falls and fear of falling associated with objectively measured physical activity in a cohort of community-dwelling older men? *BMC Geriatrics*, *14*(1).

Joseph, C., Albert, C. H., Richard, G. B., & Jonathan, G. (2022). *Forefoot and midfoot pain in the active child or skeletally immature adolescent: Overview of causes*. UpToDate.

Jung, D. Y., Kim, M. H., Koh, E. K., Kwon, O. Y., Cynn, H. S., & Lee, W. H. (2011). A comparison in the muscle activity of the abductor hallucis and the medial longitudinal arch angle during toe curl and short foot exercises. *Physical Therapy in Sport*, *12*(1), 30–35.

Kachoosangy, R. A., Aliabadi, F., & Ghorbani, M. (2013). Prevalence of Flat Foot: Comparison between Male and Female Primary School Students. In *Iranian Rehabilitation Journal* (Vol. 11, Issue 18).

Kanatlı, U., Aktas, E., & Yetkin, H. (2016). Do corrective shoes improve the development of the medial longitudinal arch in children with flexible flat feet? *Journal of Orthopaedic Science*, *21*(5), 662–666.

Kapandji, I. A. (1970). *The Physiology of the Joints*. Churchill Livingston.

Kapdule, P., Pol, T., & Th, B. P. (2019). Relationship between Core Stability and Physical Activity in Young Adults. *International Journal of Health Sciences & Research (Www.Ijhsr.Org)*, *9*(7), 126.

Karakaya, M. G., Rutbİl, H., Akpinar, E., Yildirim, A., & Karakaya, İ. Ç. (2015). Effect of ankle proprioceptive training on static body balance. *Journal of Physical Therapy Science*, *27*(10), 3299–3302.

Khadanga, G. B., & Kumar, P. (2022). Prevalence of Flat Foot in College Going Students: A Cross Sectional Study. *Malaysian Journal of Medical Research (MJMR)*, *6*(3).

Kim, M.-K. (2015). Foot pressure analysis of adults with flat and normal feet at different gait speeds on an ascending slope. *Journal of Physical Therapy Science*, *27*(12), 3767–3769.

Klimczak, K., Kochanski, B., Kaluzny, K., Plaskiewicz, A., Smucynski, W., Ratuszek-Sadowska, D., Wozniak, K., & Zukow, W. (2014). The analysis of foot defects in children aged 6-10 years. *Journal of Health Sciences*, *4*(2), 29–38.

Knapp, P. W., & Constant, D. (2022). Posterior Tibial Tendon Dysfunction. *In: StatPearls*.

Kodithuwakku Arachchige, S. N. K., Chander, H., & Knight, A. (2019). Flat feet: Biomechanical implications, assessment and management. In *Foot* (Vol. 38, pp. 81–85). Churchill Livingstone.

Kohls-Gatzoulis, J., Woods, B., Angel, J. C., & Singh, D. (2009). The prevalence of symptomatic posterior tibialis tendon dysfunction in women over the age of 40 in England. *Foot and Ankle Surgery*, *15*(2), 75–81.

Koshino, Y., Samukawa, M., Chida, S., Okada, S., Tanaka, H., Watanabe, K., Chijimatsu, M., Yamanaka, M., & Tohyama, H. (2020). Postural Stability and Muscle Activation Onset during Double- to Single-Leg Stance Transition in Flat-Footed Individuals. *Journal of Sports Science & Medicine*, *19*(4), 662–669.

Krejcie, R. v, & Morgan, D. W. (1970). DETERMINING SAMPLE SIZE FOR RESEARCH ACTIVITIES. In *EDUCATIONAL AND PSYCHOLOGICAL MEASUREMENT* (Vol. 30).

Kulig, K., Lee, S.-P., Reischl, S. F., & Noceti-DeWit, L. (2015). Effect of Posterior Tibial Tendon Dysfunction on Unipedal Standing Balance Test. *Foot & Ankle International*, *36*(1), 83–89.

Ledoux, W. R., Shofer, J. B., Ahroni, J. H., Smith, D. G., Sangeorzan, B. J., & Boyko, E. J. (n.d.). *Biomechanical Differences Among Pes Cavus, Neutrally Aligned, and Pes Planus Feet in Subjects with Diabetes*.

Levangie, Pamela K, Norkin, & Cynthia C. (n.d.). *Joint Structure and Function*.

Levinger, P., Murley, G. S., Barton, C. J., Cotchett, M. P., McSweeney, S. R., & Menz, H. B. (2010). A comparison of foot kinematics in people with normal- and flat-arched feet using the Oxford Foot Model. *Gait and Posture*, *32*(4), 519–523.

Lin, Y.-C., Mhuircheartaigh, J. N., Lamb, J., Kung, J. W., Yablon, C. M., & Wu, J. S. (2015). Imaging of Adult Flatfoot: Correlation of Radiographic Measurements With MRI. *American Journal of Roentgenology*, *204*(2), 354–359.

Lovett, H. W., & Dane, J. (1896). The affections of the arch of the foot commonly classified as flat-foot. *JBJS*, *1*(1), 78–92.

Lucasti, C. J., Dworkin, M., Warrender, W. J., Winters, B., Cohen, S., Ciccotti, M., & Pedowitz, D. (2020). Ankle and Lower Leg Injuries in Professional Baseball Players. *The American Journal of Sports Medicine*, *48*(4), 908–915.

Marouvo, J., Castro, M. A., Azevedo, N., Sousa, F., & Fernandes, O. (2021). Postural stability assessment in flatfoot subjects trough lyapunov exponent analysis. *European Journal of Public Health*, *31*(Supplement_2).

McGuine, T. A., Greene, J. J., Best, T., & Leverson, G. (2000). Balance As a Predictor of Ankle Injuries in High School Basketball Players. *Clinical Journal of Sport Medicine*, *10*(4), 239–244.

Mei-Dan, O., Kahn, G., Zeev, A., Rubin, A., Constantini, N., Even, A., Nyska, M., & Mann, G. (2005). The Medial Longitudinal Arch as a Possible Risk Factor for Ankle Sprains: A Prospective Study in 83 Female Infantry Recruits. *Foot & Ankle International*, *26*(2), 180–183.

Michelson, J. D., Durant, D. M., & McFarland, E. (2002). The Injury Risk Associated with Pes Planus in Athletes. *Foot & Ankle International*, *23*(7), 629–633.

Mohd-Sidik, S., Lekhraj, R., & Foo, C. N. (2021). Prevalence, associated factors and psychological determinants of obesity among adults in Selangor, Malaysia. *International Journal of Environmental Research and Public Health*, *18*(3), 1–17.

Molund, M., Husebye, E. E., Nilsen, F., Hellesnes, J., Berdal, G., & Hvaal, K. H. (2018). Validation of a New Device for Measuring Isolated

Gastrocnemius Contracture and Evaluation of the Reliability of the Silfverskiöld Test. *Foot & Ankle International*, *39*(8), 960–965.

N. AlKhouli, M., Ghait, A. S., & Abogazya, A. A. (2017). Relationship between flatfoot and Q angle in male secondary school studetns. *International Journal of Physiotherapy and Research*, *5*(6), 2477–2481.

Okezue, O. C., Akpamgbo, O. A., Antoninus Ezeukwu, O., John, J. N., & John, D. O. (2019). *Nov Tech Arthritis Bone Res Adult Flat Foot and its Associated Factors: A Survey among Road Traffic Officials*. *3*.

Okoroha, K. R., Conte, S., Makhni, E. C., Lizzio, V. A., Camp, C. L., Li, B., & Ahmad, C. S. (2019). Hamstring Injury Trends in Major and Minor League Baseball: Epidemiological Findings From the Major League Baseball Health and Injury Tracking System. *Orthopaedic Journal of Sports Medicine*, *7*(7), 232596711986106.

Onodera, A. N., Sacco, I. C. N., Morioka, E. H., Souza, P. S., Sá, M. R. de, & Amadio, A. C. (2008). What is the best method for child longitudinal plantar arch assessment and when does arch maturation occur? *The Foot*, *18*(3), 142–149.

Park, D. Y., Rubenson, J., Carr, A., Mattson, J., Besier, T., & Chou, L. B. (2011). Influence of stretching and warm-up on Achilles tendon material properties. *Foot and Ankle International*, *32*(4), 407–413.

Park, S.-Y., Bang, H.-S., & Park, D.-J. (2018). Potential for foot dysfunction and plantar fasciitis according to the shape of the foot arch in young adults. *Journal of Exercise Rehabilitation*, *14*(3), 497–502.

Periyasamy, R., & Anand, S. (2013). The effect of foot arch on plantar pressure distribution during standing. *Journal of Medical Engineering & Technology*, *37*(5), 342–347.

Petrofsky, J., Donatelli, R., Laymon, M., & Lee, H. (2020). Greater Postural Sway and Tremor during Balance Tasks in Patients with Plantar Fasciitis Compared to Age-Matched Controls. *Healthcare*, *8*(3), 219.

Pfeiffer, M., Kotz, R., Ledl, T., Hauser, G., & Sluga, M. (2006). Prevalence of Flat Foot in Preschool-Aged Children. *Pediatrics*, *118*(2), 634–639.

Pita-Fernandez, S., Gonzalez-Martin Cristina, Alonso-Tajes, F., Seoane-Pillado, T., Pertega-Diaz, S., Perez-Garcia, S., Seijo-Bestilleiro, R., & Balboa-Barreiro, V. (2017). Flat Foot in a Random Population and its Impact on Quality of Life and Functionality. *JOURNAL OF CLINICAL AND DIAGNOSTIC RESEARCH*.

Plisky, P. J., Gorman, P. P., Butler, R. J., Kiesel, K. B., Underwood, F. B., & Elkins, B. (2009). The reliability of an instrumented device for measuring components of the star excursion balance test. *North American Journal of Sports Physical Therapy : NAJSPT*, *4*(2), 92–99.

Pourghasem, M., Kamali, N., Farsi, M., & Soltanpour, N. (2016). Prevalence of flatfoot among school students and its relationship with BMI. *Acta Orthopaedica et Traumatologica Turcica*, *50*(5), 554–557.

Pourkazemi, F., Hiller, C. E., Raymond, J., Black, D., Nightingale, E. J., & Refshauge, K. M. (2018). Predictors of recurrent sprains after an index lateral ankle sprain: a longitudinal study. *Physiotherapy*, *104*(4), 430–437.

Raj, M. A., Tafti, D., & Kiel, J. (2022). *Pes Planus*. https://www.ncbi.nlm.nih.gov/books/NBK430802/

Ray, J. J., Friedmann, A. J., Hanselman, A. E., Vaida, J., Dayton, P. D., Hatch, D. J., Smith, B., & Santrock, R. D. (2019). Hallux Valgus. *Foot & Ankle Orthopaedics*, *4*(2), 247301141983850.

Reddy, G. P. K., & Kishve, P. (2021). Prevalence of flat foot among medical students and its impact on quality of life and functionality. *International Journal of Research in Medical Sciences*, *9*(4), 1082.

Reimers, J., Pedersen, B., & Brodersen, A. (1995). Foot Deformity and the Length of the Triceps Surae in Danish Children Between 3 and 17 Years Old. *Journal of Pediatric Orthopaedics B*, *4*(1), 71–73.

Ross, M. H., Smith, M. D., Mellor, R., Durbridge, G., & Vicenzino, B. (2021). Clinical Tests of Tibialis Posterior Tendinopathy: Are They Reliable, and How Well Are They Reflected in Structural Changes on Imaging? *Journal of Orthopaedic & Sports Physical Therapy*, *51*(5), 253–260.

Ross, M. H., Smith, M. D., Mellor, R., & Vicenzino, B. (2018). Exercise for posterior tibial tendon dysfunction: a systematic review of randomised clinical trials and clinical guidelines. *BMJ Open Sport & Exercise Medicine*, *4*(1), e000430.

Santos, M. J., & Liu, W. (2008). Possible Factors Related to Functional Ankle Instability. *Journal of Orthopaedic & Sports Physical Therapy*, *38*(3), 150–157.

Senthil Prabhu, V., Kesavi, D., Kayalvizhi, E., & Senthilprabhu, V. (2018). Prevalence of Flatfoot among Adolescents by Using Navicular Drop Test. INTRODUCTION. *IJSRR*, *2018*(4), 2519–2525.

Shariff, S. M., Manaharan, T., Shariff, A. A., & Merican, A. F. (2017). Evaluation of foot arch in adult women: Comparison between five different footprint parameters. *Sains Malaysiana*, *46*(10), 1839–1848.

Sharma, J., & Upadhyaya, P. (2016). Effect of flat foot on the running ability of an athlete. *Indian Journal of Orthopaedics Surgery*, *2*(1), 119.

Spink, M. J., Fotoohabadi, M. R., & Menz, H. B. (2010). Foot and Ankle Strength Assessment Using Hand-Held Dynamometry: Reliability and Age-Related Differences. *Gerontology*, *56*(6), 525–532.

Stein, B. E., & Schon, L. C. (2015). Posterior tibial tendon dysfunction in the adult: current concepts. *Instructional Course Lectures*, *64*, 441–450.

Stolzman, S., Irby, M. B., Callahan, A. B., & Skelton, J. A. (2015). Pes planus and paediatric obesity: a systematic review of the literature. *Clinical Obesity*, *5*(2), 52–59.

Sung, P. S., Zipple, J. T., Andraka, J. M., & Danial, P. (2017). The kinetic and kinematic stability measures in healthy adult subjects with and without flat foot. *The Foot*, *30*, 21–26.

Suryadinata, R. V., Wirjatmadi, B., Adriani, M., & Lorensia, A. (2020). Effect of Age and Weight on Physical Activity. *Journal of Public Health Research*, *9*(2), jphr.2020.1840.

Svoboda, Z., Bizovska, L., Gonosova, Z., Linduska, P., Kovacikova, Z., & Vuillerme, N. (2019). Effect of aging on the association between ankle muscle strength and the control of bipedal stance. *PloS One*, *14*(10), e0223434.

Tahmasebi, R., Karimi, M. T., Satvati, B., & Fatoye, F. (2015). Evaluation of standing stability in individuals with flatfeet. *Foot and Ankle Specialist*, *8*(3), 168–174.

Talati, D., Patil, R., & Malwade, M. (2018). Influence of leg dominance on flat foot in healthy adults. *GJRA - Global Journal For Research Analysis*, *7*(2).

Tománková, K., Přidalová, M., & Gába, A. (2015). The impact of obesity on foot morphology in women aged 48 years or older. *Acta Gymnica*, *45*(2), 69–75.

Towers, J. D., Deible, C. T., & Golla, S. K. (2003). Foot and Ankle Biomechanics. In *Seminars in Musculoskeletal Radiology* (Vol. 7, Issue 1).

Truszczyńska-Baszak, A., Drzał-Grabiec, J., Rachwał, M., Chałubińska, D., & Janowska, E. (2017). Correlation of physical activity and fitness with arches of the foot in children. *Biomedical Human Kinetics*, *9*(1), 19–26.

van der Wees, P. J., Lenssen, A. F., Hendriks, E. J. M., Stomp, D. J., Dekker, J., & de Bie, R. A. (2006). Effectiveness of exercise therapy and manual mobilisation in acute ankle sprain and functional instability: A systematic review. *Australian Journal of Physiotherapy*, *52*(1), 27–37.

Wang, J., Daniel Latt, L., Martin, R. D., & Mannen, E. M. (2022). Postural Control Differences between Patients with Posterior Tibial Tendon Dysfunction and Healthy People during Gait. *International Journal of Environmental Research and Public Health*, *19*(3).

World Health Organization. (2013). *Priority diseases and reasons for inclusion: low back pain.* World Health Organization. https://www.who.int/medicines/areas/priority_medicines/Ch6_24LBP.pdf.

Zhang, M., Nie, M.-D., Qi, X.-Z., Ke, S., Li, J.-W., Shui, Y.-Y., Zhang, Z.-Y., Wang, M., & Cheng, C.-K. (2022). A Strong Correlation Between the Severity of Flatfoot and Symptoms of Knee Osteoarthritis in 95 Patients. *Frontiers in Surgery*, *9*, 936720.

APPENDICES

APPENDIX A

ETHICAL APPROVAL LETTER

UNIVERSITI TUNKU ABDUL RAHMAN

Wholly Owned by UTAR Education Foundation (Company No. 578227-M)

Re: U/SERC/224/2022

4 November 2022

Mr Muhammad Noh Zulfikri Bin Mohd Jamali
Head, Department of Physiotherapy
M. Kandiah Faculty of Medicine and Health Sciences
Universiti Tunku Abdul Rahman
Jalan Sungai Long
Bandar Sungai Long
43000 Kajang, Selangor

Dear Mr Muhammad Noh,

Ethical Approval For Research Project/Protocol

We refer to your application for ethical approval for your students' research project from Bachelor of Physiotherapy (Honours) programme enrolled in course UMFD3026. We are pleased to inform you that the application has been approved under Expedited Review.

The details of the research projects are as follows:

No	Research Title	Student's Name	Supervisor's Name	Approval Validity
1.	Knowledge and Attitude Towards Overweight and Obesity Among Physiotherapy and Medical Students: A Cross-Sectional Study	Ching Yung Shan		
2.	Effects of Different Gluteal Strengthening Programs on Strength, Pain, Functional Disability and Balance Among University Students with Non-specific Chronic Low Back Pain: A Randomized Controlled Trial	Lee Kah Yi	Mr Muhammad Noh Zulfikri Bin Mohd Jamali	
3.	Effects on Menstrual Cycle on Dynamic Balance and Muscle Strength Among Recreational Players	Ler Chai Hong		
4.	Knowledge and Awareness Towards Pneumonia Among UTAR Non-Health Sciences Undergraduate Students	Chooi Yan Yee	Pn Nurul Husna Binti Khairuddin	
5.	The Effect of Active Video Games on 6-Minute Walk Test in Overweight and Obese Children	Chin Jay Ven		4 November 2022 – 3 November 2023
6.	Association of Functional Ability of Upper Extremity and Scoliosis Among College Students: A Correlational Study	Sammi Leong Sing Yee		
7.	A Correlation Study Between Achilles Tendon Contracture and Posterior Tibial Tendon Dysfunction on Ankle Instability Among Young Adults with Pes Planus	See Wan Ni	Dr Deepak Thazhakkattu Vasu	
8.	A Correlational Study of the Relationship Between Flat Foot with Anterior Pelvic Tilt and Sacroiliac Joint Dysfunction Among Undergraduate Students	Tan Bee Thong		
9.	Association Between Physical Activity, Learning Style and Academic Performance Among UTAR Health Science Undergraduates	Yeoh Zhe Yi	Ms Kamala a/p Krishnan	

Kampar Campus : Jalan Universiti, Bandar Barat, 31900 Kampar, Perak Darul Ridzuan, Malaysia
Tel: (605) 468 8888 **Fax:** (605) 466 1313
Sungai Long Campus : Jalan Sungai Long, Bandar Sungai Long, Cheras, 43000 Kajang, Selangor Darul Ehsan, Malaysia
Tel: (603) 9086 0288 **Fax:** (603) 9019 8868
Website: www.utar.edu.my

No	Research Title	Student's Name	Supervisor's Name	Approval Validity
31.	Association of Postural Awareness with Sedentary Behavior and Back Pain During the Hybrid Study Among Undergraduate Students	Low Xin Yuen	Mr Martin Ebenezer Chellappan	4 November 2022 – 3 November 2023
32.	Impact of Social Media Addiction on Physical Activity Among Undergraduate Students	Mak Kai Nan		
33.	Tibial Torsion and Leg Length Discrepancy in Idiopathic Scoliosis Among UTAR Students	Khoo Wan Qi	Pn Nadia Safirah Binti Rusli	
34.	Prevalence of Patellofemoral Pain Among University Students	Khoo Wen Han		
35.	Prevalence of Varicose Veins Among Fast Food Employees in Cheras, Selangor: A Cross Sectional Study	Ropheca Phuah Su Hui		
36.	The Effect of Unstable Modified Wall Squat on Dynamic Balance Among Recreational Athletes	Chu Sin Jiet	Mr Sathish Kumar Sadagobane	
37.	Knowledge, Perception, and Attitude Towards Breast Cancer and Breast Self-Examination (BSE) Among Non-medical Private University Students	Foo Jes Mynn		
38.	Perception, Knowledge and Attitude Towards the Impact of Daytime Nap on the Risk of Stroke Among Non-Healthcare Undergraduate Students: A Cross-Sectional Study	Chan Chi Kuan	Mr Tarun Amalnerkar Co-Supervisor: Ms Swapneela Jacob	
39.	Awareness, Knowledge and Attitude Toward Orthostatic Hypotension Among Elderlies	Ch'ng Hui Kee		
40.	Effect of TikTok on Student Learning Among Physiotherapy Students	Tan Eng Jing	Mr Avanianban Chakkarapani	
41.	Awareness Towards Tourette Syndrome Among Health Science and Non-health Science Students in A Private University, Malaysia	Tan Kai Xuan		
42.	Effect of Scapular Retraction Exercise on Forward Head Posture Among University Students	Tay Kai Wei	Ms Mahadevi A/P Muthurethina Barathi	
43.	Comparison Between Effect of Lower Limb Cyclic Stretching and Ballistic Stretching on Jumping Distance Among Undergraduate Students: A Comparative Study	Ng Zi Ru		
44.	Relationship of Physical Activity with Anxiety and Depression Among University Students	Ong Aiwei		
45.	Gender Discrepancy and Its Association with Shoulder Pain Among Malaysian Recreational Badminton Players	Khoo Je-Yique	Pn Nur Aqliliriana Binti Zainuddin	
46.	Obesity, Eating Habits and Physical Activity Before and During Covid-19 Pandemic Among University Lecturers	Khoo Tze Sean		

The conduct of this research is subject to the following:

(1) The participants' informed consent be obtained prior to the commencement of the research;

(2) Confidentiality of participants' personal data must be maintained; and

(3) Compliance with procedures set out in related policies of UTAR such as the UTAR Research Ethics and Code of Conduct, Code of Practice for Research Involving Humans and other related policies/guidelines.

(4) Written consent be obtained from the institution(s)/company(ies) in which the physical or/and online survey will be carried out, prior to the commencement of the research.

Should the students collect personal data of participants in their studies, please have the participants sign the attached Personal Data Protection Statement for records.

Thank you.

Yours sincerely,

Professor Ts Dr Faidz bin Abd Rahman
Chairman
UTAR Scientific and Ethical Review Committee

c.c Dean, M. Kandiah Faculty of Medicine and Health Sciences
Director, Institute of Postgraduate Studies and Research

Kampar Campus : Jalan Universiti, Bandar Barat, 31900 Kampar, Perak Darul Ridzuan, Malaysia
Tel: (605) 468 8888 **Fax**: (605) 466 1313
Sungai Long Campus : Jalan Sungai Long, Bandar Sungai Long, Cheras, 43000 Kajang, Selangor Darul Ehsan, Malaysia
Tel: (603) 9086 0288 **Fax**: (603) 9019 8868
Website: www.utar.edu.my

APPENDIX B

APPLICATION FOR VENUE BOOKING

KaiYee Foo Swee Ping
to me, Encik, Samantha, Phoebe, Puan, Valle, Nandakumari

Fri, Nov 4, 10:47 AM

This message has been deleted. Restore message

Dear Ms Wan Ni,

Good day.

We received your venue booking form and herein below is your venue booking details for your attention. **Kindly notify us earlier if the venue booking is cancelled or rescheduled.**

Date : 7th, 8th, 9th, 15th & 17th November 2022
Time : 8.30 am to 12.30 pm + 1.30 pm to 5.00 pm *(lunch hour 1230-1330 & Center close at 1700)*
Purpose : Physiotherapy FYP Data Collection
Capacity : **Can provide the number of participants?**
Venue : **KA200A** (2nd Floor Physio Center)

Date : 11th November 2022 (Friday)
Time : 8.30 am to 12.30 pm + 2.00 pm to 5.00 pm *(lunch hour 1230-1400 & Center close at 1700)*
Purpose : Physiotherapy FYP Data Collection
Capacity : **Can provide the number of participants?**
Venue : **KA200A** (2nd Floor Physio Center)

Thank you very much.

Stay safe and stay healthy!

Warm regards.

Wan Hidayati Binti Wan Hamzah <hidayati@utar.edu.my>
to me, Nandakumari, Valle, KaiYee, Samantha, Phoebe

Tue, Nov 22, 3:51 PM (8 days ago)

Dear Ms. See Wan Ni,

We have received your venue booking form and herein below your venue booking details for your attention:-

Date : 25/11/2022 (Friday)
Time : **8.30 am to 12.30 pm** & **2.00 pm to 5.00 pm** (Fri lunch hour 1230-1400)
Venue : **KA102** (1st Floor Physio Centre)
No. of Pax: 4
Purposes: Final Year Project Data Collection
Programme : PS

Please notify us earlier if the venue booking is cancelled or rescheduled.

Thank you.
--
Warmest Regards,

Wan Hidayati binti Wan Hamzah
Administrative Assistant II
M.Kandiah Faculty of Medicine and Health Sciences (MK FMHS)
Faculty General Office (FGO)
Sungai Long Campus
Tel: +603-9086 0288 (Ext: 184)

APPENDIX C

APPLICATION FOR EQUIPMENT BOOKING

Weighing machine Inbox ×

Nandakumari A/P P Velayan @ Sabapathy <nandakumari@utar.edu.my> Tue, Nov 22, 4:56 PM
to Muhammad, me, Deepak

Dear Mr Haquim,

We would like to borrow a weighing machine from your place to the Physiotherapy exercise room(KA102).

Details are as follows
Borrower Name:Ms Tan Bee(megan)
Date :25/11/22
Time:8.30 -5.00 pm
Returning Date:28/11/22

Thank you.

--
Regards,

Ms Nandakumari Sabapathy
Physiotherapist II
Department of Physiotherapy
M. Kandiah Faculty of Medicine and Health Sciences
University Tunku Abdul Rahman
Sg Long Campus.
ext 152

APPENDIX D

PERSONAL DATA PROTECTION STATEMENT

Please be informed that in accordance with Personal Data Protection Act 2010 (“PDPA”) which came into force on 15 November 2013, Universiti Tunku Abdul Rahman (“UTAR”) is hereby bound to make notice and require consent in relation to collection, recording, storage, usage and retention of personal information.

1. Personal data refers to any information which may directly or indirectly identify a person which could include sensitive personal data and expression of opinion. Among others it includes:
a) Name
b) Identity card
c) Place of Birth
d) Address
e) Education History
f) Employment History
g) Medical History
h) Blood type
i) Race
j) Religion
k) Photo
l) Personal Information and Associated Research Data

2. The purposes for which your personal data may be used are inclusive but not limited to:
a) For assessment of any application to UTAR
b) For processing any benefits and services
c) For communication purposes
d) For advertorial and news
e) For general administration and record purposes
f) For enhancing the value of education
g) For educational and related purposes consequential to UTAR
h) For replying any responds to complaints and enquiries
i) For the purpose of our corporate governance
j) For the purposes of conducting research/ collaboration

3. Your personal data may be transferred and/or disclosed to third party and/or UTAR collaborative partners including but not limited to the respective and appointed outsourcing agents for purpose of fulfilling our obligations to you in respect of the purposes and all such other purposes that are related to the purposes and also in providing integrated services, maintaining and storing records. Your data may be shared when required by laws and when disclosure is necessary to comply with applicable laws.

4. Any personal information retained by UTAR shall be destroyed and/or deleted in accordance with our retention policy applicable for us in the event such information is no longer required.

5. UTAR is committed in ensuring the confidentiality, protection, security and accuracy of your personal information made available to us and it has been our ongoing strict policy to ensure that your personal information is accurate, complete, not misleading and updated. UTAR would also ensure that your personal data shall not be used for political and commercial purposes.

6. By submitting or providing your personal data to UTAR, you had consented and agreed for your personal data to be used in accordance to the terms and conditions in the Notice and our relevant policy.

7. If you do not consent or subsequently withdraw your consent to the processing and disclosure of your personal data, UTAR will not be able to fulfill our obligations or to contact you or to assist you in respect of the purposes and/or for any other purposes related to the purpose.

8. You may access and update your personal data by writing to us at wannisee@1utar.my

Acknowledgment of Notice
[ ] I have been notified and that I hereby understood, consented and agreed per UTAR above notice.
[ ] I disagree, my personal data will not be processed.

…………………………
Name:
Date:

APPENDIX E

INFORMATION SHEET AND CONSENT FORM

Research Participant Information Sheet

Universiti Tunku Abdul Rahman
M. Kandiah Faculty of Medicine and Health Sciences
Department of Physiotherapy
Bachelor of Physiotherapy (Honours)

Information Sheet to Participate in the Study
A Correlation Study between Achilles Tendon Contracture and Posterior Tibial Tendon Dysfunction on Ankle Instability Among Young Adults with Pes Planus

Student Investigator: See Wan Ni
Department: Physiotherapy
Course Name and Course Code: UMFD3026 Research Project
Year and Semester: Year 3 Semester 2
Supervisor: Dr. Deepak Thazhakkattu Vasu

You are being asked to volunteer for this research study that is being conducted as part of the requirement to complete the above mentioned course.

Please read this information sheet and contact me to ask any questions that you may have before agreeing to take part in this study.

Purpose of the Research Study
The purpose of this study is to determine and compare the correlation of Achilles tendon contracture and posterior tibial tendon dysfunction on ankle instability among young adults with pes planus.

Approximately 401 students will participate in this study.

Procedures
If you agree to be in this study, you will be going through a total of 3 stations once you are found to be eligible through screening conducted by our examiner.

Screening for pes planus (flat foot):
You will be asked to print your footprints on a piece of paper after stepping on the footprint ink mat.

Proceed to station 1 if found to have CSI of $\geq 45\%$.

Station 1 – Presence of Achilles tendon contracture:
In this station, you will be asked to take off your shoes. You will be positioned in lying. To test the tightness of your calf muscles, you will be asked to point

your toes towards the ceiling while your knee is kept in bend and in straighten position. The angle of your ankle moved will be measured and recorded down.

Station 2 – Presence of posterior tibial tendon dysfunction:
In this station, you will be asked to take off your shoes. In standing, you will be instructed to lift your heel up as high as possible from the floor by one leg. Then, repeat on the other side of the leg.

Station 3 – Y balance test:
This station is to measure your balance. Shoe wearing is allowed, sport shoes are recommended in this station. You will be standing on the platform of the balance kit in the middle, by standing on 1 leg, you will need to push the reach indicator in 3 different direction by your free leg while maintaining the heel of standing leg in contact. A demonstration will be performed first by the examiner and you will be given 6 trials to familiarize with the test. On the start of the test, you are given with 3 chance to push the reach indicator as far as possible, the average value will be taken from the 3 trials attempted. Afterwards, the length of your leg will be measured in lying by the examiner.

Upon completing all stations, you will be notified with your result of the tests.

Length of Participation
This study will be conducted for approximately 30 minutes.

Risks and Benefits
There are no risks from being in this study.

By participating in this study, participants may be benefited with diagnosis on pes planus that was previously unaware, along with series of screening to rule out other associating factors. The produced results of this study will help to help physiotherapist in formulating effective program to prevent and managing ankle instability among individuals with pes planus. Hence, preventing increasing risk of injury to occur as a result of ankle instability.

Confidentiality

No information that will make it possible to identify you, will be included in any reports to the University or in any publications.
Research records will be stored securely and only approved researchers will have access to the records.

Voluntary Nature of the Study

Participation in this study is voluntary. If you withdraw or decline participation, you will not be penalized or lose benefits or services unrelated to the study. If you decide to participate, you may decline to answer any question and may choose to withdraw at any time.

Contacts and Questions

If you have any questions, clarifications, concerns or complaints, about the research, the researcher conducting this study can be contacted at 017-2075409 and wannisee@1utar.my
Our supervisor can be contacted at Dr. Deepak Thazhakkattu Vasu, deepak@utar.edu.my, concerns, or complaints about the research and wish to talk to someone other than individuals on the research team.

Please keep this information sheet for your records.

Research Participant Consent Form

Universiti Tunku Abdul Rahman
M. Kandiah Faculty of Medicine and Health Sciences
Department of Physiotherapy
Bachelor of Physiotherapy (Honours)

Consent Form to Participate in the Study
A Correlation Study between Achilles Tendon Contracture and Posterior Tibial Tendon Dysfunction on Ankle Instability Among Young Adults with Pes Planus

Student Investigator: See Wan Ni
Department: Physiotherapy
Course Name and Course Code: UMFD3026 Research Project
Year and Semester: Year 3 Semester 2
Supervisor: Dr. Deepak Thazhakkattu Vasu

I have read the provided information, or it has been read to me. I have had the opportunity to ask questions about it and any questions I have, has been answered to my satisfaction. I understand that I will be given a copy of this form, and the researcher will keep another copy on file. I consent voluntarily to be a participant in this study.

Name of Participant: ______________________________

IC No: ____________________ Date: _______________

APPENDIX F

DEMOGRAPHIC DATA COLLECTION FORM

Demographic data collection - Screening

iamwannisee@gmail.com Switch accounts

*Required

Email *

Your email address

Personal Data Protection Statement

Please be informed that in accordance with Personal Data Protection Act 2010 ("PDPA") which came into force on 15 November 2013, Universiti Tunku Abdul Rahman ("UTAR") is hereby bound to make notice and require consent in relation to collection, recording, storage, usage and retention of personal information.

Notice

1. Personal data refers to any information which may directly or indirectly identify a person which could include sensitive personal data and expression of opinion. Among others it includes:
a) Name
b) Identity card
c) Place of Birth
d) Address
e) Education History
f) Employment History
g) Medical History
h) Blood type
i) Race
j) Religion
k) Photo
l) Personal Information and Associated Research Data

2. The purposes for which your personal data may be used are inclusive but not limited to:
a) For assessment of any application to UTAR
b) For processing any benefits and services
c) For communication purposes
d) For advertorial and news
e) For general administration and record purposes
f) For enhancing the value of education
g) For educational and related purposes consequential to UTAR

g) For educational and related purposes consequential to UTAR
h) For replying any responds to complaints and enquiries
i) For the purpose of our corporate governance
j) For the purposes of conducting research/ collaboration

3. Your personal data may be transferred and/or disclosed to third party and/or UTAR collaborative partners including but not limited to the respective and appointed outsourcing agents for purpose of fulfilling our obligations to you in respect of the purposes and all such other purposes that are related to the purposes and also in providing integrated services, maintaining and storing records. Your data may be shared when required by laws and when disclosure is necessary to comply with applicable laws.

4. Any personal information retained by UTAR shall be destroyed and/or deleted in accordance with our retention policy applicable for us in the event such information is no longer required.

5. UTAR is committed in ensuring the confidentiality, protection, security and accuracy of your personal information made available to us and it has been our ongoing strict policy to ensure that your personal information is accurate, complete, not misleading and updated. UTAR would also ensure that your personal data shall not be used for political and commercial purposes.

Consent

6. By submitting or providing your personal data to UTAR, you had consented and agreed for your personal data to be used in accordance to the terms and conditions in the Notice and our relevant policy.

7. If you do not consent or subsequently withdraw your consent to the processing and disclosure of your personal data, UTAR will not be able to fulfill our obligations or to contact you or to assist you in respect of the purposes and/or for any other purposes related to the purpose.

8. You may access and update your personal data by writing to us at wannisee@1utar.my

Acknowledgment of Notice *

- ◯ I have been notified and that I hereby understood, consented and agreed per UTAR above notice
- ◯ I disagree, my personal data will not be processed.

Electronic Signature (Eg. Electronically s/d Initials/Nickname) *
For example: Electronically s/d Megan

Your answer

Part 1: Demographic Data

Name *

Your answer

Student ID *

Your answer

Age *

Choose

Gender *

- Male
- Female
- Prefer not to say

Are you aware that you have flat foot? *

- Yes (Prcoceed to next question)
- No (Skip next question and press "Next")

Since when you are diagnosed with flat foot?

- Since birth
- Since conscious
- Others

Part 2: History of Injuries

Q1 Have you injured/sprained your ankle previously? *

- ◯ Yes
- ◯ No

Q2 If yes, how long ago? *

If no just choose not applicable

- ◯ Less than one month
- ◯ More than one month
- ◯ Not applicable

Q3 Which side of your ankle injured/sprained? *

If no just choose not applicable

- ◯ Left
- ◯ Right
- ◯ Both
- ◯ Not applicable

Q4 Had you underwent corrective surgery for your foot in the past 1 month? *

- ◯ Yes
- ◯ No

Q5 Had you experienced any knee injuries? *

Eg.: MCL/LCL tear

- ◯ Yes
- ◯ No

Part 3: Activity Participations

Activity level *

Choose

Sport(s) involved? *

Your answer

Frequency of sport(s) participations *

- ○ None
- ○ Once a week
- ○ Twice a week
- ○ Three or more a week

APPENDIX G

ASSESSMENT FORM

Name:

Student ID:

Height (cm):	Weight (kg):			BMI:		
	RIGHT			**LEFT**		
Dominant side						
a (cm) b (cm) CSI (%)						
Dorsiflexion (º): (1) Knee Flexed: (2) Knee Extended:						
SHRT (+/-)						
Y Balance (3 trials): (1) Maximum reach distance (cm): Antero: Posteromedial: Posterolateral: Sum of all 3 direction:	1	2	3	1	2	3
(2) Limb length (cm):						
(3) Composite score (%):						

APPENDIX H

TURNITIN REPORT

Document Viewer

Turnitin Originality Report

Processed on: 22-Dec-2022 21:14 +08
ID: 1985727617
Word Count: 30466
Submitted: 1

A CORRELATION STUDY BETWEEN ACHILLES TENDON C... By Wan Ni See

Similarity Index	Similarity by Source	
6%	Internet Sources:	5%
	Publications:	2%
	Student Papers:	N/A

include quoted | include bibliography | excluding matches < 1% | mode: quickview (classic) report | print | refresh | download

2% match (Internet from 11-Oct-2022)
http://eprints.utar.edu.my

2% match (Internet from 14-Sep-2021)
http://www.ijsrp.org

1% match (Internet from 10-Oct-2022)
http://eprints.utar.edu.my

1% match (Andrew Prestwich, Mark Conner, Rebecca Lawton, Wendy Bailey, Jessica Litman, Victoria Molyneaux. "Individual and collaborative implementation intentions and the promotion of breast self-examination", Psychology & Health, 2005)
Andrew Prestwich, Mark Conner, Rebecca Lawton, Wendy Bailey, Jessica Litman, Victoria Molyneaux. "Individual and collaborative implementation intentions and the promotion of breast self-examination", Psychology & Health, 2005

1% match (Internet from 16-Dec-2022)
https://ir.unimas.my/id/eprint/32257/2/Jessica%20full.pdf

ii CHAPTER 1 INTRODUCTION 1.1 Background of Study Stability is a complex motor task which involving the integration of sensory information on body postures and appropriate motor response of the musculoskeletal system for postural control in respect to the influence of internal and external environment factors (Karakaya et al., 2015). It is inevitable that stability plays a major role in maintaining the centre of gravity of an individual within the base of support. However, this is unable to be achieved without a good stability of the ankle joint. As the first major joint that