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Posture Alterations in Students of the Degree in Physical Education and Sports at the University of Madeira

Relationship with Body Composition and Physical Activity Profiles

MASTER DISSERTATION

Sadaf Ashraf
MASTER IN PHYSICAL ACTIVITY AND SPORTS

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ABSTRACT

Poor body alignment, sedentary behaviors, and various physical activity levels experienced by young adults lead to musculoskeletal imbalances and subsequent discomforts, which, when left undetected and untreated, significantly impact the quality of life. This study aims to evaluate the postural alterations of students enrolled in Physical activity and sports degrees at the University of Madeira and the impact of their body composition and physical activity.

Using a postural assessment table by two physiotherapists, this study examined postural alterations in 231 university students (165 men, 66 women) aged 22.64±4.86 years. Their physical activity profile and body composition were assessed using Baecke's Habitual PA questionnaire and Inbody770, respectively. The Kolmogorov-Smirnov test examined the quantitative variable distribution normality. Descriptive statistics, including mean and standard deviation, characterized the sample. The chi-frame test determined gender differences in the prevalence of postural changes. The T-Student test examined the differences between participants with and without postural changes in quantitative variables with a normal distribution. The software used was SPSS version 7.0; the significance level adopted was 5%.

Results showed that the most common spinal alteration was *scoliosis* (56.7%), followed by *kyphosis* (53.2%) and *lordosis* (14.3%), being more prevalent in males than females. The most common alteration in the foot and knee was *pes planus* and *genu recurvatum*, respectively. Physical activity profile indicated a statistically significant relationship with *lordosis*; however, it was negatively correlated with the prevalence of other spinal, knee, and foot alterations. Conversely, body composition was positively associated with the prevalence of knee *genu recurvatum,* and height and weight were positively associated with *scoliosis*.

These findings highlight the importance of evaluating postural alterations for early detection and intervention to reduce further negative impacts on the spine and other body parts. It also helps adults engaging in competitive sports or related to physical education to become aware of their postural alteration in different individuals.

KEYWORDS: Knee Deformities, Foot Deformities, Body Composition and Physical Activity.

RESUMO

A postura é uma atitude ou posição corporal mantida em repouso, assumida durante uma determinada atividade, ou uma forma precisa de apoiar o corpo em que este faz modificações rápidas ao longo do tempo para reduzir o gasto de energia. A boa postura é um estado harmonioso dos sistemas esquelético e muscular que protege as estruturas de suporte do corpo contra a degeneração progressiva e as lesões. O mau alinhamento corporal, os comportamentos sedentários e os diferentes níveis de atividade física dos jovens adultos conduzem a desequilíbrios músculo-esqueléticos e consequentes desconfortos que, quando não detectados e tratados, têm um impato significativo na qualidade de vida. Este estudo tem como objectivo avaliar as alterações posturais dos alunos inscritos nas licenciaturas de atividade física e desporto da universidade da madeira e o impato da sua composição corporal e atividade física. Utilizando uma tabela de avaliação postural por dois fisioterapeutas, este estudo examinou as alterações posturais em 231 estudantes universitários (165 homens, 66 mulheres), com idades entre 22,64±4,86 anos. O seu perfil de atividade física e a sua composição corporal foram avaliados através do questionário habitual pa de baecke e do inbody770, respectivamente. O teste de kolmogorov-Smirnov examinou a normalidade da distribuição das variáveis quantitativas. A estatística descritiva, incluindo a média e o desvio padrão, caracterizou a amostra. O teste do qui-quadrado determinou as diferenças de género na prevalência de alterações posturais. O teste t-student analisou as diferenças entre os participantes com e sem alterações posturais em variáveis quantitativas com distribuição normal. O software utilizado foi o spss versão 7.0; o nível de significância adoptado foi de 5%. Os resultados mostraram que a alteração da coluna vertebral mais comum foi a escoliose (56,7%), seguida da cifose (53,2%) e da lordose (14,3%), sendo mais prevalente no sexo masculino do que no feminino. A alteração mais comum no pé e no joelho foi o pé plano e o joelho recurvo, respectivamente. O perfil de atividade física indicou uma relação estatisticamente significativa com a lordose; no entanto, foi negativamente correlacionado com a prevalência de outras alterações da coluna, joelho e pé. Por outro lado, a composição corporal foi positivamente associada à prevalência de joelho genu recurvatum e a altura e o peso foram positivamente associados à escoliose. Estes resultados sublinham a importância de avaliar as alterações posturais para detecção e intervenção precoces, a fim de reduzir outros impatos negativos na coluna vertebral e noutras partes do corpo. Ajuda também os adultos que praticam desportos de competição ou relacionados com a educação física a tomarem consciência das suas alterações posturais e também em diferentes indivíduos.

PALAVRAS-CHAVE: Deformações do joelho, Deformações do pé, Composição corporal e Atividade física.

RESUMÉ

La posture est une attitude ou une position du corps maintenue au repos, adoptée au cours d'une activité donnée, ou une manière précise de soutenir le corps dans laquelle il se modifie rapidement au fil du temps pour réduire la dépense d'énergie. Une bonne posture est un état harmonieux des systèmes squelettique et musculaire qui protège les structures de soutien du corps contre la dégénérescence progressive et les blessures. Un mauvais alignement corporel, des comportements sédentaires et des niveaux d'activité physique différents chez les jeunes adultes entraînent des déséquilibres musculo-squelettiques et des malaises conséquents qui, lorsqu'ils ne sont pas détectés et traités, ont un impact significatif sur la qualité de vie. Cette étude vise à évaluer les changements posturaux des étudiants inscrits dans les diplômes d'activité physique et de sport à l'université de Madère et l'impact de leur composition corporelle et de leur activité physique. À l'aide d'un tableau d'évaluation posturale par deux physiothérapeutes, cette étude a examiné les changements posturaux chez 231 étudiants universitaires (165 hommes, 66 femmes), âgés de 22,64 ± 4,86 ans. Leur profil d'activité physique et leur composition corporelle ont été évalués à l'aide des questionnaires habituels pa de baecke et inbody770, respectivement. Le test de Kolmogorov-Smirnov a examiné la distribution normale des variables quantitatives. Les statistiques descriptives, y compris la moyenne et l'écart-type, ont caractérisé l'échantillon. Le test du chi carré a déterminé les différences entre les sexes dans la prévalence des changements posturaux. Le test t-student a analysé les différences entre les participants avec et sans changements posturaux dans les variables quantitatives avec une distribution normale. Le logiciel utilisé était spss version 7.0; le seuil de signification retenu était de 5 %. Les résultats ont montré que l'altération la plus courante de la colonne vertébrale était la scoliose (56,7%), suivie de la cyphose (53,2%) et de la lordose (14,3%), étant plus fréquente chez les hommes que chez les femmes. L'altération la plus fréquente du pied et du genou était respectivement le pied plat et le genou recourbé. Le profil d'activité physique indiquait une relation statistiquement significative avec la lordose ; cependant, il était corrélé négativement avec la prévalence d'autres troubles de la colonne vertébrale, du genou et du pied. D'autre part, la composition corporelle était positivement associée à la prévalence du genu recurvatum du genou et la taille et le poids étaient positivement associés à la scoliose. Ces résultats soulignent l'importance d'évaluer les changements posturaux pour une détection et une intervention précoces afin de réduire d'autres impacts négatifs sur la colonne vertébrale et d'autres parties du corps. Il aide également les

adultes qui pratiquent des sports de compétition ou des sports liés à l'éducation physique à prendre conscience de leurs changements posturaux et aussi chez différents individus.

MOTS- CLÉS: Déformations du genou, Déformations du pied, Composition corporelle et Activité physique.

RESUMEN

La postura es una actitud o posición corporal mantenida en reposo, asumida durante una actividad determinada, o una forma precisa de apoyar el cuerpo en la que éste realiza rápidas modificaciones a lo largo del tiempo para reducir el gasto energético. Una buena postura es un estado armonioso de los sistemas esquelético y muscular que protege las estructuras de soporte del cuerpo de la degeneración progresiva y las lesiones. La mala alineación corporal, los comportamientos sedentarios y los diferentes niveles de actividad física entre los adultos jóvenes provocan desequilibrios musculoesqueléticos y las consiguientes molestias que, cuando no se detectan y tratan, tienen un impacto significativo en la calidad de vida. Este estudio tiene como objetivo evaluar los cambios posturales de los estudiantes matriculados en los grados de actividad física y deporte en la universidad de Madeira y el impacto de su composición corporal y la actividad física. Utilizando una tabla de evaluación postural realizada por dos fisioterapeutas, este estudio examinó los cambios posturales en 231 estudiantes universitarios (165 hombres, 66 mujeres), de 22,64 ± 4,86 años. Su perfil de actividad física y composición corporal se evaluaron mediante los cuestionarios habituales pa de baecke e inbody770, respectivamente. La prueba de Kolmogorov-Smirnov examinó la distribución normal de las variables cuantitativas. Las estadísticas descriptivas, incluida la media y la desviación estándar, caracterizaron la muestra. La prueba de chi-cuadrado determinó diferencias de género en la prevalencia de cambios posturales. La prueba t-student analizó las diferencias entre participantes con y sin cambios posturales en variables cuantitativas con distribución normal. El software utilizado fue spss versión 7.0; el nivel de significación adoptado fue del 5%. Los resultados mostraron que la alteración más frecuente de la columna vertebral fue la escoliosis (56,7 %), seguida de la cifosis (53,2 %) y la lordosis (14,3 %), siendo más prevalente en el sexo masculino que en el femenino. La alteración más frecuente en pie y rodilla fue pie plano y rodilla recurvada, respectivamente. El perfil de actividad física indicó una relación estadísticamente significativa con la lordosis; sin embargo, se correlacionó negativamente con la prevalencia de otros trastornos de la columna, la rodilla y el pie. Por otro lado, la composición corporal se asoció positivamente con la prevalencia de rodilla genu recurvatum y la altura y el peso se asociaron positivamente con la escoliosis. Estos resultados subrayan la importancia de evaluar los cambios posturales para la detección e intervención tempranas con el fin de reducir más impactos negativos en la columna vertebral y otras partes del cuerpo. También ayuda a los adultos que practican deportes de competición o deportes

relacionados con la educación física a tomar conciencia de sus cambios posturales y también en diferentes individuos.

PALABRAS - CLAVE: Deformidades de la rodilla, Deformidades del pie, Composición corporal y Actividad física.

GENERAL INDEX

Index of Abbreviations

BMI --- Body Mass Index.

BMR --- Basal Metabolic Rate.

PA --- Physical Activity.

SPSS --- Statistical Package for Social Sciences

%MG --- Percentage Magnesium

Q-angle --- Quadriceps angle.

With alt. --- With alterations.

Without alt. --- Without alterations.

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CHAPTER 1 – INTRODUCTION

Chapter 1 – Introduction

1.1. Introduction

Posture is an attitude or body position maintained at rest, assumed during a particular activity, or a precise way of supporting the body in which it makes quick modifications over time to reduce energy expenditure (Smith et al., 1996). Posture is maintained by skeletal muscle contraction, coordinated by a series of external stimuli, and through continuous neuromuscular type modifications, representing the body's reaction to the force of gravity (Barker, 1998). Good Posture is a harmonious state of skeletal and muscular systems that guard the body's supporting structures against progressive degeneration and injury (Britnell et al., 2005).

The spine is a primordial element of Posture and is defined as a collection of small bones that are layered and moveable amid one another, acting as an axis for the rest of the skeleton and guarding the spinal cord (Kapandji, 2000). The spinal column's balance depends on the sum of all forces exerted, including forces by passive structures, active structures, and neural control (Fritz et al., 1998; Panjabi, 1992). The human body typically has four curves, two primary and two secondary, that help to withstand external forces and the pull of gravity (Kendall et al., 2005).

Anterior curves, also called *lordosis*, are found in cervical and lumbar regions, while the posterior curve, also known as *kyphosis*, is located in the thoracic and sacral regions (Kendall et al., 2005), as shown in Figure 1. Postural changes occur along soft tissue constraints and impair flexibility and strength when continually accentuating these curves (Kisner et al., 2017). Changes in spinal alignment can harm children's or adolescents' quality of life concerning their health, including substantial problems with the intervertebral discs and several degenerative disorders (Berven & Wadhwa, 2018). The most significant musculoskeletal growth and development occur during childhood, hence a good posture from an early age, timely correction, and the preventive nature that must be ingrained in school will have long-term, likely permanent, favorable effects on the person (Iunes et al., 2008). Inappropriate habits adopted by humans, as a large, result from bad habits practiced at the early stages of life, leading to severe damages that will likely interfere with the individual's present and future health (Mello et al., 2004).

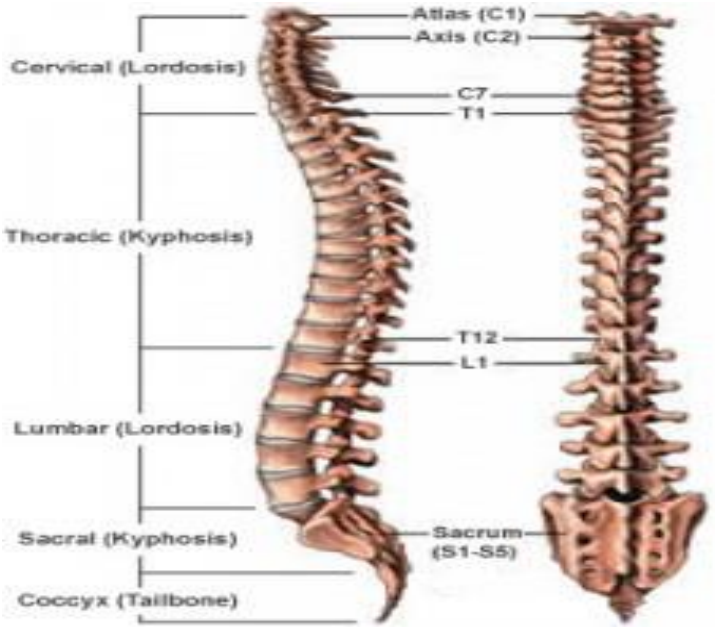

Figure 1: Spinal Curves (MD, 2017)

Common alterations like *scoliosis*, *hyperlordosis*, or spondylosis can develop in people with aberrant ligament strains due to holding a particular position for an extended period (Fransoo, 2003). Every abnormal increase in muscle tone will result in an imbalance that needs to be balanced by compensatory muscle contractions (Fransoo, 2003). Muscular alterations mostly come from overuse in cases of shortening and lack of muscle reinforcement in cases of lucidity, and muscle imbalances are caused by several causes, including biomechanical, neurological, and physiological factors (Jull, 1987).

Incorrect body posture causes stress or strain on the spinal segment, which has a detrimental effect on the body, including muscle strain, a herniated disc, pinched nerve pain, depressed mood, stress, gastrointestinal issues, breathing difficulties, back and neck pain, shoulder pain, headaches, hunching over, rounding the shoulders, tilting the head forward, locking the knees, arching the low belly, and many others (Curone et al., 2010; Yi et al., 2014; Zhang et al., 2011).

The multiple contributing factors to postural impairment include inadequate education or awareness and consciousness of proper posture, a sedentary lifestyle, occupational requirements, decreased fitness, weak muscles, and an ergonomically unsound workstation (Chopra et al., 2016). Most postural issues are attributed to the way training is constructed, where there is excessive concentration on muscles responsible for the execution of the technical gesture, disregarding, almost wholly, the musculature responsible for maintaining posture

(Ragonese, 1987). It can be concluded from this statement that movement will depend directly on good posture (Westcott et al., 1997). When tested, this finding is evident in the correlation between postural alignment and muscular performance (Westcott et al., 1997). According to this line of thought, to focus attention on posture-related issues, it should carry a weight comparable to that in terms of technical characteristics, primarily due to the direct impact that this has on an individual's performance while an athlete and, as a result, the prevention of injuries (Ramos & Freitas, 1996).

This research will analyze postural deviations based on students' physical activity, body composition, and sports history. Exploring the relationship of postural deviations with physical activity, body composition, and sports history will help find the postural deviations in assessing and developing treatment programs for deformities and postures. This research will educate individuals about poor postures that might cause pain, difficulties performing activities, and a lack of interest in extracurricular activities like sports and physical education.

They could rectify these posture problems with the right workouts, awareness of postural alignment, and detect musculoskeletal issues if they are conscious of their destructive postural patterns. Standing posture analysis can help the strength and conditioning specialist create strength programming better tailored to the demands of the physical education students and athletes to improve performance and potentially lower the risk of injury. Focusing close attention on factors like age and gender and how they relate to posture can determine how to maintain it correctly in the future.

1.2. Research Question

This study aims to address the following research questions:

- Are there any postural deviations among physical education Students at the University of Madeira?
- Is there any relationship between physical activity and postural deviations?
- Is there any relationship between body composition and postural deviation?
- Is there any relationship between sports history and postural deviation?

1.3. Objectives

This research primarily aims to achieve the following objectives:

1.3.1. General Objective

To evaluate the postural changes in physical education students at the University of Madeira.

1.3.2. Specific objective

Based on their physical activity, evaluate postural changes in physical education students at the University of Madeira.

Based on their body composition, evaluate postural changes in physical education students at the University of Madeira.

Based on their sports history, evaluate postural changes in physical education students at the University of Madeira.

1.4. Structure of Dissertation

To evaluate the physical health status of students affiliated with physical education and sports, we tried to assess postural alterations in students and their body composition and physical activity profiles. Hence, six chapters structured in this work, which are described in detail below:

- **Chapter I –** Includes introduction, where this dissertation's description, relevance, theme, research questions, objectives and structure.
- **Chapter II –** Includes a Literature Review of the themes presented, with key terms such as the concept of posture, good posture, bad posture, the changes that may arise from bad posture, and proceeding with their evaluation. The literature further includes postural deviations and body composition, postural deviation and physical activity, and postural deviations and sports history.
- **Chapter III –** Includes Methodology, including study type, study setting, population and sample, a unit of analysis and statistical instruments and procedures developed during the work.
- **Chapter IV –** Includes prevalence of deformities in the foot and knee in university students and their physical activity and body composition profile. (1st Study).
- **Chapter V –** Includes postural alterations in the spine and their relationship with body composition and physical activity. (2nd Study).
- **Chapter VI –** Includes final Considerations, where the main obtained results, limitations and future recommendations, bibliographic references, and relevant annexes.

CHAPTER 2 – LITERATURE REVIEW

Chapter 2 – Literature Review

2.1. Postural Deviations

Posture is an attitude or body position maintained at rest, adopted in an activity, or an exact way of supporting the body in which it makes quick modifications over time to reduce the energy of the body, leading to a rise in muscle stress to maintain proper balance (Smith et al., 1996). Posture is maintained by skeletal muscle contraction, coordinated by a series of external stimuli, and through continuous neuromuscular type modifications, representing the body's reaction to the force of gravity (Barker, 1998).

Postural changes cause unbalanced body components, leading to a rise in muscle stress to maintain proper balance (Bernard et al., 2003). Each person has a unique and distinctive posture that may be influenced by several factors, such as ligament elasticity, breathing issues, bone malformations or changes that are either congenital or acquired, bad posture habits, protein deficiencies, excess or decreased weight, and even changes or psychological disturbances (Teixeira, 1996). Postural changes cause unbalanced body components, leading to a rise in muscle stress to maintain proper balance (Bernard et al., 2003). Although, if deviations persist, it will cause joint overload, leading to discomfort and functional impairment (Detsch et al., 2007).

Even though certain postural adjustments are related to growth, others are typical reactions to human development (Penha et al., 2005). Postures are formed early in life; among children and teenagers, postural deviations are widespread and connected to postural behaviors throughout school age, although some are typical postural growth characteristics (Asher & Lee, 1975; Oshiro et al., 2007). Children and teenagers spend a lot of time sitting down, utilizing school nags improperly, and lugging overstuffed bags of school supplies. In addition, postural muscles do not develop as rapidly as they develop, and they spend a lot of time sitting wrongly on furniture with poor ergonomics can weaken dorsal and abdominal muscles (Eitner et al., 1984; Oshiro et al., 2007). Long-term, and maybe for the rest of an individual's life, positive effects will result from having good posture from childhood, its early correction, and the preventive character that must be maintained at school because it is at this stage that the most incredible musculoskeletal growth/development occur (Campos et al., 2002).

Studies emphasize that one of the most urgent issues facing contemporary society is the widespread nature of postural abnormalities (Andrews et al., 2012; Iedynak et al., 2017;

Kashuba & Dudko, 2015; Torlakovic et al., 2014). A few of the most frequent musculoskeletal problems in modern students are functional disorders of posture (Anna et al., 2020; Dudko, 2015; Gorelov et al., 2013; Mani et al., 2015). Numerous types of research are conducted on postural changes in children going through growth and development (Candotti et al., 2010; Fornazari & Pereira, 2008; Oshiro et al., 2007).

However, very few research are conducted on the younger population affiliated with physical education. A study conducted in Ukraine on students during physical education illustrated that students had *scoliosis*, round-shouldered back and rounded back postures (Anna et al., 2020). Similarly, the evaluation of first-year physiotherapy students at the Medical University of Lodz in response to systematic motor activity indicated postural impairments, including head protruding, wrong shoulder, convex abdominal, and lumbar *lordosis* (Tomaszewska & Pawlicka-Lisowska, 2014). The emphasis on postural changes in the knee and foot is scarce. Foot and knee postures are known to determine how well the lower extremity operates and may contribute to a person's propensity for recurrent trauma (Dahle et al., 1991; Nigg et al., 1993). A study on first to fourth-grade primary school children illustrated that most individuals had no visible foot deformities (Bogut et al., 2019).

However, pathological foot abnormalities are more prevalent in adults and elderly populations (Benvenuti et al., 1995; Dunn et al., 2004). In Germany, adolescents had a 13.7% prevalence of foot deformities (Spahn et al., 2004). The foot is the terminal joint in the lower kinetic chain, providing stability and motion and opposing external resistance (Donatelli, 1985). During locomotion, the foot and leg structure enables them to handle compressive loads which exceed several times body weight (Clarke et al., 1983).

The foot is distinctive in that it is developed in the shape of arches, allowing it to modify its shape to uneven surfaces and serving as a resilient spring to absorb shocks (Snell, 2007). A healthy foot's lateral arch is elevated 3 to 5 mm from the ground's surface. In contrast, the medial longitudinal arch is elevated 15 to 18 mm from the ground's surface (Kapandji, 1987). The medial longitudinal arch is clinically significant in diseases and the functioning of joints and muscles of the ankle and knee (Franco, 1987). When the medial arch of the foot is disturbed; in that case, deformities occur, whereby considerable reduction in the arch of the foot causes *pes planus*, whereas the increase in the arch exceeding 18mm causes *pes cavus* (Oatis, 2009).

Pes planus is a biomechanical deformity comprising a plethora of physical characteristics that include excessive subtalar complex eversion during weight bearing, talus plantarflexion concerning tibia calcaneus plantar flexion, navicular dorsiflexion and abduction, forefoot supination, the valgus posture of the heel (Cappello & Song, 1998).

In *pes cavus*, the distorted position of the arch can be due to hypertonic tibialis anterior and posterior muscle; and shortened soft tissues, including tibialis posterior muscle and plantar fascia, increased tensile pressure placed on the anterior calcaneus (Lowe, 2006). *Pes cavus* can cause retraction of toes, plantarflexed forefoot and severe stress on metatarsal heads and heel (Riddick & Jorge, 2020). Furthermore, muscular imbalances in *pes cavus* cause lateral foot pain as well as bone deformities (Burns et al., 2005).

Muscle weakness, bone abnormalities, excessive body weight, inherited weakening of supportive tissue, excessive physical effort, prolonged standing, bad habits during standing and walking, and inappropriate footwear disrupts the texture of the foot leading to *pes planus* (Bogut et al., 2019). Compared to neutrally oriented feet, *pes planus* feet feature everted calcaneus, a medially deviated point of pressure and more force applied to the greater toe during gait (Ledoux & Hillstrom, 2002; Song et al., 2004). A statistically significant relationship between foot deformities and their impacts was seen in runners, indicating individuals with *pes planus* showed higher rates of medial and soft tissue injuries to foot and knee injuries, whereas individuals with *pes cavus* indicated higher rates of lateral and bony injuries and ankle injuries (Williams Iii et al., 2001). Similarly, a study conducted on an older population with diabetes indicated that *pes planus* has greater lateral talo metatarsal angles and *pes cavus* exhibited more frequency of lower extremity abnormalities like bony prominences, hammer/claw toes, and prominent metatarsal heads than in neutral foot (Ledoux et al., 2003).

The functioning of the foot transmits stress to the knee; for instance, in *pes planus* and *pes cavus*, the tibia rotates medially, and the patella experiences a more substantial bowstring effect and lateral tracking forces (Kisner et al., 2017). The knee joint is crucial for assisting the body and distributing weight while engaging in static and dynamic activities. Regarding stabilization, compressive and tensile forces applied to the knee joint are supported by ligaments and muscles but not by the bone. In that aspect, the knee joint is most susceptible to injuries in the human body (Levangie & Norkin, 2011).

Non-traumatic deformities of the knee include *Genu Recurvatum*, Genu Valgus, and Genu Varus. *Genu Recurvatum* is the position of a tibiofemoral joint in which the range of

motion occurs beyond neutral or 0º extension (Brownstein B, 1988). In genu valgus deformity, ankle joints are spaced apart when knees are in contact with each other in a weight-bearing position (Jalalvand, Fatahi, & Entezari Khorasani, 2021). In contrast, in genu varus, the internal condyles of the femur become spaced apart if they are in weight-bearing contact with the media, malleolus of the ankle (Jalalvand et al., 2021). These deformations increase the likelihood of additional complications in exposed individuals, including osteoarthritis of the tibiofemoral joint, patellofemoral joint injury, compensatory modifications in the ankle and foot joints, and risk of tibia fracture (Espandar et al., 2010; Janakiramanan et al., 2008; Yang et al., 2010).

Being overweight and obese is now so widespread among the world's population that it is starting to supplant malnutrition and infectious disease as the primary contributor to illness that impairs quality of life (Bray, 2004; Janssen et al., 2002; Kopelman, 2000). Additionally, it alters the geometry of the body, increasing the mass of different segments (Rodacki et al., 2005), and imposes functional restrictions on the biomechanics of everyday living tasks that may put the obese at risk for injury (Wearing et al., 2006). Somatic structure and body composition primarily influence body structure. Various studies indicate that an increase in body mass index leads to postural instability in young adults who are obese and non-obese (Berrigan et al., 2006; Hue et al., 2007; Maffiuletti et al., 2005). A study on students aged 7-16 in Arak City reveals a substantial correlation between age, BMI, and the occurrence of genu varum (A. Ghandi et al., 2012). A study conducted in Iran on the prevalence of genu varum revealed a strong correlation between age, BMI, and the history of lower limb trauma with or without fracture and the incidence of genu varum (A. r. Ghandi et al., 2012). But the significance of body composition with the occurrence of foot and knee deformities is not well studied among the younger population.

2.2. Postural Deviations and physical activity

Students are known to be using backpacks, possibly leading to Forward head position (FHP), rounded shoulders, *kyphosis*, low back pain, and an unbalanced axial skeleton (Bettany-Saltikov & Cole, 2012; Linders & Nuckley, 2007; Orloff & Rapp, 2004). A study on the prevalence of postural deviations in 2nd cycle students illustrated that more than 70% of individuals had postural abnormalities in all body segments, including the pelvis, neck, shoulders, trunk, feet, and center of gravity. 57.9% were significantly underweight, and 84.2% had a below-average BMI. They had an incorrect posture when seated at a table and picking something off the floor (Desouzart & Gagulic, 2017). A significant co-correlation was

discovered between the presence of thoracic *kyphosis* and the following factors: female gender; physical activity only once or twice per week; sleep duration of more than ten hours; poor postures when sitting on a seat and sitting down to write; and method of carrying school supplies (Sedrez et al., 2015).

Apart from research on children, a few pieces of research were completed on university students. After analyzing the posture, quality of life, and mental fitness of students during the process of physical education, Anna et al. (2020) concluded that students showed signs of the following postural disorders: 47.3% *scoliosis*, 19.1% round shoulder, and 16.4% showed signs of rounded backs, while only 16.9% were seated correctly (Anna et al., 2020). Moreover, the evaluation of first-year physiotherapy students at the Medical University of Lodz indicated postural impairments, including the head in protruding position, wrong shoulder position, convex abdominal positioning, and lumbar *lordosis* (Tomaszewska & Pawlicka-Lisowska, 2014).

A study conducted in 2022 with concerns about overweight and physical inactivity in children and adolescents studies the relationship between posture, gender, BMI, and physical activity. They discovered that when compared to the group of teenagers who were average weight, the obese group had a larger angle of lumbar *lordosis*, and the overweight group had a greater anteriorization of the head. The men displayed higher projection of the trunk and torso forward, while the females displayed greater head anteriorization, Q angle, and lumbar *lordosis*. Sedentary individuals had more increased scapular abduction. (A. P. O. C. de Miranda et al., 2022) Furthermore, another study indicated that *scoliosis* was linked to playing competitive sports and sleeping more than 10 hours. In contrast, lumbar *lordosis* was related to the inefficient carrying of the school backpack (Sedrez et al., 2015). This research deduces that physical inactivity and improper task mechanics can impact postural impairment development.

2.3. Postural Deviation, Body Composition and BMI

Being overweight and obese is now so widespread among the world's population that it is starting to supplant malnutrition and infectious disease as the primary contributor to illness (Kopelman, 2000). Various studies indicate that an increase in body mass index leads to postural instability in young adults who are obese and non-obese (Berrigan et al., 2006; Hue et al., 2007; Maffiuletti et al., 2005).

A study conducted on 217 adolescents of both genders in a municipal school in São Paulo found that teenagers with obesity had a large angle of lumbar *lordosis* and overweight

had greater anteriorization of the head. Males displayed higher projection of the trunk and torso forward, while the females displayed greater head anteriorization, Q angle, and lumbar *lordosis*. (A. de Miranda et al., 2022). Moreover, among university students, a study conducted at the University of Venda, South Africa, measured height and weight to assess BMI and postural deviations considered in lateral, anterior, and posterior views, found that (34%) of the participants had *kyphosis*, *lordosis* (22%) and *scoliosis* (3%); neither *kyphosis* nor *scoliosis* is significantly correlated with BMI. However, the negative association between BMI and *lordosis* indicates a higher risk of *lordosis* development as BMI rises (Malepe et al., 2015).

2.4. Postural Deviation and Sports History

The postures developed during sports activities sometimes potentiate muscle problems, skeletal muscle issues, and an increased risk of injury (Kritz & Cronin, 2008). Therefore, it is crucial to identify any changes as soon as possible, even in children, and to encourage people to adopt healthy postures as a preventative measure to lessen symptoms like pain and discomfort (Penha et al., 2005). Few researchers could insite postural deviations among physical education students and their sports history. However, research was done by Bogdanovic and Markovic to identify whether primary school students have lordotic posture based on their reasons for not participating in sports but only focused on the basis for not participating in sports. Their research illustrated that bad lordotic posture was prevalent in 32.60% of students living far away, 31% due to high fees, and 29.56% for wrong reasons (Bogdanović & Marković, 2010).

There is no evidence of a study that has taken all the aspects, i.e., physical activity, body composition, BMI, and sports history, in evaluating the postural deviations among physical education students. Henceforth, in this study, we will look at individuals' postural deviations in three planes, anterior, lateral, and posterior, by analyzing their body composition, BMI, and amount of physical activity they perform. We will also explore individuals' past and present sports within the scope of a federation, association, or club, namely the modality practiced, weekly frequency, duration per session, the context of the competition (regional, national, and international), and several years of federated practice.

Bibliographic References

Andrews, D. M., Fiedler, K. M., Weir, P. L., & Callaghan, J. P. (2012). The effect of posture category salience on decision times and errors when using observation-based posture assessment methods. *Ergonomics, 55*(12), 1548-1558.

Anna, H., Olena, A., Vitalii, K., Igor, N., Serhiy, C., Inna, K., . . . Andriy, M. (2020). Characteristics of biogeometric profile of posture and quality of life of students during the process of physical education.

Asher, C. J., & Lee, M. (1975). Diagnosis and correction of nutritional disorders in ginger.

Barker, V. (1998). *Postura, posizione, movimento per potenziare le prestazioni sessuali, rimodellare il corpo, ritardare l'invecchiamento, ridurre l'obesità, sviluppare le capacità*: Edizioni Mediterranee.

Benvenuti, F., Ferrucci, L., Guralnik, J. M., Gangemi, S., & Baroni, A. (1995). Foot pain and disability in older persons: an epidemiologic survey. *Journal of the American Geriatrics Society, 43*(5), 479-484.

Bernard, P., Geraci, M., Hue, O., Amato, M., Seynnes, O., & Lantieri, D. (2003). *Influence of obesity on postural capacities of teenagers. Preliminary study.* Paper presented at the Annales de readaptation et de medecine physique: revue scientifique de la Societe francaise de reeducation fonctionnelle de readaptation et de medecine physique.

Berrigan, F., Simoneau, M., Tremblay, A., Hue, O., & Teasdale, N. (2006). Influence of obesity on accurate and rapid arm movement performed from a standing posture. *International Journal of Obesity, 30*(12), 1750-1757.

Berven, S., & Wadhwa, R. (2018). Sagittal alignment of the lumbar spine. *Neurosurgery Clinics, 29*(3), 331-339.

Bettany-Saltikov, J., & Cole, L. (2012). The effect of frontpacks, shoulder bags and handheld bags on 3D back shape and posture in young university students: an ISIS2 study. *Stud Health Technol Inform, 176*, 117-121.

Bogdanović, Z., & Marković, Ž. (2010). Presence of lordotic poor posture resulted by absence of sport in primary school children. *Acta kinesiologica, 4*(1), 63-66.

Bogut, I., Popović, Ž., Tomac, Z., Matijević, V., & Radmilović, G. (2019). Prevalence of foot deformities in young schoolchildren in Slavonia. *Acta Clinica Croatica, 58*(2.), 288-294.

Bray, G. A. (2004). Medical consequences of obesity. *The Journal of clinical endocrinology & metabolism, 89*(6), 2583-2589.

Britnell, S., Cole, J., Isherwood, L., Stan, M., Britnell, N., Burgi, S., . . . Watson, L. (2005). Postural health in women: the role of physiotherapy. *Journal of obstetrics and gynaecology Canada, 27*(5), 493-500.

Brownstein B, N. F., Mangine RE, Kryger S. (1988). *Physical Therapy of the Knee: Anatomy and biomechanics. In: Mangine RE (ed)*. New York: Churchill Livingstone.

Burns, J., Crosbie, J., Hunt, A., & Ouvrier, R. (2005). The effect of pes cavus on foot pain and plantar pressure. *Clinical biomechanics, 20*(9), 877-882.

Campos, F. d. S., Silva, A. S. d., & Fisberg, M. (2002). Descrição fisioterapêutica das alterações posturais de adolescentes obesos. *Braz Pediatr News, 4*(2).

Candotti, C. T., Macedo, C. H., Noll, M., & de Freitas, K. (2010). Escola de postura: uma metodologia adaptada aos pubescentes. *Revista Mackenzie de Educação Física e Esporte, 9*(2).

Cappello, T., & Song, K. M. (1998). Determining treatment of flatfeet in children. *Current opinion in pediatrics, 10*(1), 77-81.

Chopra, S., Kumar, M., & Sood, S. (2016). *Wearable posture detection and alert system.* Paper presented at the 2016 International Conference System Modeling & Advancement in Research Trends (SMART).

Clarke, T., Frederick, E., & Cooper, L. (1983). Effects of shoe cushioning upon ground reaction forces in running. *International journal of sports medicine, 4*(04), 247-251.

Curone, D., Bertolotti, G. M., Cristiani, A., Secco, E. L., & Magenes, G. (2010). A real-time and self-calibrating algorithm based on triaxial accelerometer signals for the detection of human posture and activity. *IEEE transactions on information technology in biomedicine, 14*(4), 1098-1105.

Dahle, L. K., Mueller, M., Delitto, A., & Diamond, J. E. (1991). Visual assessment of foot type and relationship of foot type to lower extremity injury. *Journal of Orthopaedic & Sports Physical Therapy, 14*(2), 70-74.

de Miranda, A., Penha, P. J., Pereira, L. G., Pessoa, W. C., & João, S. M. A. (2022). Posture of Adolescent and the Relationship with Body Mass Index, Sex, and Physical Activity. *Child Obes, 18*(5), 342-349. doi:10.1089/chi.2021.0191

de Miranda, A. P. O. C., Penha, P. J., Pereira, L. G., Pessoa, W. C., & João, S. M. A. (2022). Posture of Adolescent and the Relationship with Body Mass Index, Sex, and Physical Activity. *Childhood Obesity, 18*(5), 342-349.

Desouzart, G., & Gagulic, S. (2017). Analysis of postural changes in 2nd cycle students of elementary school. *J Spine, 6*(1), 1000357.

Detsch, C., Luz, A. M. H., Candotti, C. T., Oliveira, D. S. d., Lazaron, F., Guimarães, L. K., & Schimanoski, P. (2007). Prevalência de alterações posturais em escolares do ensino médio em uma cidade no Sul do Brasil. *Revista Panamericana de Salud Publica, 21*(4), 231-238.

Donatelli, R. (1985). Normal biomechanics of the foot and ankle. *Journal of Orthopaedic & Sports Physical Therapy, 7*(3), 91-95.

Dudko, M. (2015). Characteristic of bio-geometric profile of students' posture and physical fitness in process of physical education. *Physical education of students, 19*(4), 10-16.

Dunn, J., Link, C., Felson, D., Crincoli, M., Keysor, J., & McKinlay, J. (2004). Prevalence of foot and ankle conditions in a multiethnic community sample of older adults. *American journal of epidemiology, 159*(5), 491-498.

EITNER, D., KUPRIAN, W., MEISSNER, L., & ORK, H. (1984). Fisioterapia nos esportes. Tradução por Angela G. Marx. In: São Paulo: editora Manole.

Espandar, R., Mortazavi, S. M.-J., & Baghdadi, T. (2010). Angular deformities of the lower limb in children. *Asian journal of sports medicine, 1*(1), 46.

Fornazari, L. P., & Pereira, V. C. G. (2008). Prevalência de postura escoliótica em escolares do ensino fundamental. *Cadernos da Escola de Saúde, 1*(1).

Franco, A. H. (1987). Pes cavus and pes planus: analyses and treatment. *Physical therapy, 67*(5), 688-694.

Fransoo, P. (2003). *EXAMEN CLÍNICO DEL PACIENTE CON LUMBALGIA. Compendio práctico de reeducación* (Vol. 87): Editorial Paidotribo.

Fritz, J. M., Erhard, R. E., & Hagen, B. F. (1998). Segmental instability of the lumbar spine. *Physical therapy, 78*(8), 889-896.

Ghandi, A., Hadi, H., Behruzi, A., & Holakooie, A. (2012). The prevalence of genu-varum in students aged 7-16 in Arak city.

Gorelov, A., Kondakov, V., & Belikova, Z. A. (2013). About necessity of use of Hatha Yoga exercises for correction of deformation of students' spine of special medical groups with violations of posture. *Physical education of students, 17*(2), 35-44.

Hue, O., Simoneau, M., Marcotte, J., Berrigan, F., Doré, J., Marceau, P., . . . Teasdale, N. (2007). Body weight is a strong predictor of postural stability. *Gait & posture, 26*(1), 32-38.

Iedynak, G., Galamandjuk, L., Kyselytsia, O., Nakonechnyi, I., Hakman, A., & Chopik, O. (2017). Special aspects of changes in physical readiness indicators of young men with different somatotypes between 15 and 17 years of age. *Journal of Physical Education and Sport, 17*(4), 2690-2696.

Iunes, D., Monte-Raso, V., Santos, C., Castro, F., & Salgado, H. (2008). Postural influence of high heels among adult women: analysis by computerized photogrammetry. *Brazilian Journal of Physical Therapy, 12*, 454-459.

Jalalvand, H., Fatahi, A., & Entezari Khorasani, Z. (2021). Comparison of the Kinematic Pattern of Knee Joint Flexion in Healthy and Genu Valgum and Genu Varum Children During Jumping. *Journal of Sport Biomechanics, 7*(4), 270-279. doi:10.32598/biomechanics.7.4.294.2

Janakiramanan, N., Teichtahl, A. J., Wluka, A. E., Ding, C., Jones, G., Davis, S. R., & Cicuttini, F. M. (2008). Static knee alignment is associated with the risk of unicompartmental knee cartilage defects. *Journal of Orthopaedic Research, 26*(2), 225-230.

Janssen, I., Katzmarzyk, P. T., & Ross, R. (2002). Body mass index, waist circumference, and health risk: evidence in support of current National Institutes of Health guidelines. *Archives of internal medicine, 162*(18), 2074-2079.

JULL, G. J. (1987). Muscles and motor control in low back pain. *Physical therapy of the low back*.

Kapandji, A. (2000). Fisiologia articular: Esquemas comentados de mecânica humana. *Ed. Rio de Janeiro: Panamericana, 3*.

Kapandji, I. A. (1987). The physiology of the joint. *lower limb., 2*.

Kashuba, V., & Dudko, M. (2015). Sovremennye podkhody, metodiki i tekhnologii k formirovaniiu zdorovogo obraza zhizni studentov v processe fizicheskogo vospitaniia [Modern approaches to, methodic and technologies of students' healthy life style formation in process of physical education]. *Fizichne vikhovannia, sport i kul'tura zdorov'ia u suchasnomu suspil'stvi, 1*, 52-57.

Kendall, F., McCreary, E., & Provance, P. Muscle testing and function with posture and pain, ed 4, Baltimore, 1993. In: Williams & Wilkins.

Kisner, C., Colby, L. A., & Borstad, J. (2017). *Therapeutic exercise: foundations and techniques*: Fa Davis.

Kopelman, P. G. (2000). Obesity as a medical problem. *Nature, 404*(6778), 635-643.

Kritz, M. F., & Cronin, J. (2008). Static posture assessment screen of athletes: Benefits and considerations. *Strength & Conditioning Journal, 30*(5), 18-27.

Ledoux, W. R., & Hillstrom, H. J. (2002). The distributed plantar vertical force of neutrally aligned and pes planus feet. *Gait & posture, 15*(1), 1-9.

Ledoux, W. R., Shofer, J. B., Ahroni, J. H., Smith, D. G., Sangeorzan, B. J., & Boyko, E. J. (2003). Biomechanical differences among pes cavus, neutrally aligned, and pes planus feet in subjects with diabetes. *Foot & ankle international, 24*(11), 845-850.

Levangie, P. K., & Norkin, C. C. (2011). *Joint structure and function: a comprehensive analysis*: FA Davis.

Linders, D., & Nuckley, D. (2007). Deduction of spinal loading from vertebral body surface strain measurements. *Experimental mechanics, 47*(3), 303-310.

Lowe, W. (2006). *Orthopedic Assessment in Massage Therapy*: Daviau Scott.

Maffiuletti, N., Agosti, F., Proietti, M., Riva, D., Resnik, M., Lafortuna, C., & Sartorio, A. (2005). Postural instability of extremely obese individuals improves after a body weight

reduction program entailing specific balance training. *Journal of endocrinological investigation*, *28*(3), 2-7.
Malepe, M., Goon, D., Anyanwu, F., & Amusa, L. (2015). The relationship between postural deviations and body mass index among university students. *Biomedical Research, 26*(3), 437-442.
Mani, R., Milosavljevic, S., & Sullivan, S. J. (2015). Control of posture during tasks representing common work-related postures–a reliability study. *Ergonomics, 58*(6), 980-989.
MD, W. C. (2017). Basic Spinal Anatomy. Retrieved from 6580 Main Street, Suite 2 Williamsville, NY 14221 t (716) 881-0382 or 1-888-325-7374 f (716) 881-042
Mello, E. D. d., Luft, V. C., & Meyer, F. (2004). Childhood obesity: towards effectiveness. *Jornal de pediatria, 80*, 173-182.
Nigg, B. M., Cole, G. K., & Nachbauer, W. (1993). Effects of arch height of the foot on angular motion of the lower extremities in running. *Journal of biomechanics, 26*(8), 909-916.
Oatis, C. A. (2009). *Kinesiology the mechanics and pathomechanics of human movement*: Wolters Kluwer.
Orloff, H. A., & Rapp, C. M. (2004). The effects of load carriage on spinal curvature and posture. *Spine, 29*(12), 1325-1329.
Oshiro, V. A., Ferreira, P. G., & da Costa, R. F. (2007). Alterações posturais em escolares: uma revisão da literatura postural deviations in schoolchildren: a literature review. *Revista de Atenção à Saúde, 5*(13).
Panjabi, M. M. (1992). The stabilizing system of the spine. Part II. Neutral zone and instability hypothesis. *Journal of spinal disorders, 5*, 390-390.
Penha, P. J., João, S. M. A., Casarotto, R. A., Amino, C. J., & Penteado, D. C. (2005). Postural assessment of girls between 7 and 10 years of age. *clinics, 60*, 9-16.
Ragonese, G. (1987). Compensação muscular. *Rio Claro: Unesp, Instituto de Biociências*.
Ramos, P., & Freitas, T. (1996). Estudo da incidência de alterações posturais em atletas de alto rendimento da equipe Reebok/Funilense, que participaram dos Jogos Olímpicos de Atlanta–1996. *Presidente Prudente: FCT*.
Riddick, D. A., & Jorge, M. (2020). Footwear: Foundation for Lower Extremity Orthoses. *Orthotics and Prosthetics in Rehabilitation; Elsevier: Amsterdam, The Netherlands*, 164-182.
Rodacki, A. L. F., Fowler, N. E., Provensi, C. L. G., Rodacki, C. d. L. N., & Dezan, V. H. (2005). Body mass as a factor in stature change. *Clinical biomechanics, 20*(8), 799-805.
Sedrez, J. A., Rosa, M. I. Z. d., Noll, M., Medeiros, F. d. S., & Candotti, C. T. (2015). Risk factors associated with structural postural changes in the spinal column of children and adolescents. *Revista Paulista de Pediatria, 33*, 72-81.
Smith, L. K., Weiss, L., & Lehmkuhl, L. D. (1996). Brunnstrom's clinical kinesiology.
Snell, R. S. (2007). *Clinical anatomy by systems*: Lippincott Williams & Wilkins.
Song, M.-Y., Chung, W.-S., Kim, S.-S., & Shin, H.-D. (2004). Correlation between obesity and lumbar lordosis in obese pre-menupausal Korean females. *J Korean Orient Med, 25*, 43-50.
Spahn, G., Schiele, R., Hell, A., Klinger, H., Jung, R., & Langlotz, A. (2004). The prevalence of pain and deformities in the feet of adolescents. Results of a cross-sectional study. *Zeitschrift fur Orthopadie und ihre Grenzgebiete, 142*(4), 389-396.
Teixeira, L. (1996). Importância do movimento humano na relação homem/trabalho: Aspectos posturais.
Tomaszewska, A., & Pawlicka-Lisowska, A. (2014). Evaluation of an influence of systematic motor activity on the body posture of young people. *Polski Merkuriusz Lekarski: Organ Polskiego Towarzystwa Lekarskiego*, *36*(215), 336-340.

Torlakovic, A., Muftic, M., Radjo, I., Talovic, M., & Mahmutovic, I. (2014). Evolution of sports-medical team management in the program of posture correction in children. *Materia socio-medica, 26*(2), 104.

Wearing, S., Hennig, E., Byrne, N., Steele, J., & Hills, A. (2006). The biomechanics of restricted movement in adult obesity. *Obesity reviews, 7*(1), 13-24.

Westcott, S. L., Lowes, L. P., & Richardson, P. K. (1997). Evaluation of postural stability in children: current theories and assessment tools. *Physical therapy, 77*(6), 629-645.

Williams Iii, D. S., McClay, I. S., & Hamill, J. (2001). Arch structure and injury patterns in runners. *Clinical biomechanics, 16*(4), 341-347.

Yang, N. H., Nayeb-Hashemi, H., Canavan, P. K., & Vaziri, A. (2010). Effect of frontal plane tibiofemoral angle on the stress and strain at the knee cartilage during the stance phase of gait. *Journal of Orthopaedic Research, 28*(12), 1539-1547.

Yi, W.-J., Sarkar, O., Mathavan, S., & Saniie, J. (2014). *Wearable sensor data fusion for remote health assessment and fall detection.* Paper presented at the IEEE International Conference on Electro/Information Technology.

Zhang, Y., Markovic, S., Sapir, I., Wagenaar, R. C., & Little, T. D. (2011). *Continuous functional activity monitoring based on wearable tri-axial accelerometer and gyroscope.* Paper presented at the 2011 5th International Conference on Pervasive Computing Technologies for Healthcare (PervasiveHealth) and Workshops.

CHAPTER 3 – METHODOLOGY

Chapter 3 – Methodology

3.1. Study Type

It is a quantitative study collecting data from students with Degrees in Physical Education and Sports and Master's in Teaching Physical Education in Basic and Secondary Education at the University of Madeira. Postural changes, physical activity, body composition, and sports history were evaluated.

3.2. Study Setting

This study collected data from students with Degrees in Physical Education and Sports and Master's in Teaching Physical Education in Basic and Secondary Education at the University of Madeira. The students were made to complete questionnaires to evaluate their physical activity and sports history. As a second part, their body composition was observed through INbody 770 manufactured by Inbody organization owned by Kichul Cha, and postural changes were assessed by two physiotherapists.

3.3. Time Horizon

The data were collected within six months.

3.4. Unit of Analysis

The units of analysis for this study were postural changes, body composition, physical activity, and sports history.

3.5. Population and Sample

3.5.1. Population

This study included 231 adults who were students from the Physical Education and Sports course at the University of Madeira. The sample included 165 men and 66 women aged between 18 and 44 years old (22.5 ± 4.2 years). All participants were healthy and not injured at the time of data collection. The optimal sample size was calculated using G*Power (Faul et al., 2009). A priori independent samples t-test indicated a total sample of 128 participants (64 in each group) to attain 80% power for an effect size of 0.50 at the 0.05 level of significance. All the procedures implemented in the current study received ethical approval from the Scientific Committee of The Faculty of Physical Education and Sports at the University of

Madeira (reference: ACTA N.77-12 April 2016). All participants were volunteers, and informed consent was signed before data collection.

3.5.1.1. Inclusion Criteria

- Students enrolled in Degree in Physical Education and Sports at the University of Madeira.
- Students enrolled in Master's in Teaching Physical Education in Basic and Secondary Education at the University of Madeira.

3.5.1.2. Exclusion Criteria

- Students not enrolled in a Degree in Physical Education and Sports at the University of Madeira.
- Students not enrolled in Master's in Teaching Physical Education in Basic and Secondary Education at the University of Madeira.
- Students non-healthy or injured.
- Partial or external students
- Students on mobility (ERASMUS)

3.5.2. General Procedures

3.5.2.1. Scale/ Measures

3.5.2.1.1. Postural Evaluation

The postural evaluation was conducted using the Postural Assessment Table, employing the visual assessment method. The evaluation was carried out by two experienced physiotherapists who were trained in postural assessment techniques. A similar process of postural assessment was employed, as described by [32], in a study involving rhythmic gymnasts and non-trainees to observe the presence of postural alterations. The subjects under observation were assessed while standing in three distinct views: anterior, side, and posterior. Before the assessment, participants were instructed to present themselves barefoot and in light clothing. They assumed a neutral standing position, with specific guidance given regarding their gaze direction (looking forward and fixing their gaze on a point on a wall). Data collection spanned two weeks, during which assessments were conducted for each relevant class. These assessments took place in a dedicated physical performance laboratory between 10 a.m. and 2 p.m. on weekdays. Each evaluation session lasted approximately 40 min, allowing sufficient time for participants to complete consent forms and undergo testing. The decision to conduct assessments during regular working hours was deliberate, aiming to mitigate potential biases

related to participants' alertness and concentration levels. Moreover, this approach ensured consistent conditions for all participants, promoting the overall validity of the research findings. By allocating uniform time slots for assessment sessions, the study sought to enhance the reliability and credibility of the collected data.

3.5.2.1.2. In the Anterior View

Overall body symmetry was observed, including head position looking for tilting and rotations (alignment of the ears, nose, eyes and chin), alignment of clavicles (horizontalization and verticalization), alignment of the shoulders (front and back), hand position (observed position relative to the torso), arm spacing (space to the side of torso), alignment of the torso (position of the umbilicus and sternum in relation to the line of gravity), alignment of the iliac crest (symmetric or asymmetric), alignment of the knee (internal, external rotation, varus and valgus), foot position (inversion and eversion), malleolus (symmetry and asymmetry).

3.5.2.1.3. In the Side View

Overall body symmetry was evaluated, including head position (cervical curvature), shoulders (forward rounding and protraction of scapulae), shoulder anteriorization and posteriorization, spinal curves (for thoracic *kyphosis*, lumbar *lordosis*, or flat-back position), pelvis (anteroversion and retroversion), knees (flexion and extension for genu recurvatum), and feet (medial longitudinal arch for planus and cavus).

3.5.2.1.4. In the posterior View

Overall body symmetry was assessed, including head (alignment of ears), neck (alignment concerning shoulders – forward head and neck or backward), shoulders (elevation, depression, anterior tilting, protraction and retraction), vertical alignment of spine observed and palpated (*scoliosis*), posterior superior iliac spine (symmetry and asymmetry), popliteal lines (symmetry and asymmetry) and feet (valgus and varus).

3.5.2.2. Body Composition

Stature was measured to the nearest 0.01 cm using a stadiometer (SECA 213, Hamburg, Germany). Body composition variables were assessed using hand-to-foot bioelectrical impedance analysis (InBody 770, Cerritos, CA, USA). Body mass, body mass index (BMI), fat mass percentage (FM%), total body water (TBW), Intracellular Water, Extracellular Water, protein, minerals, and skeletal muscle mass (SMM), and **waist-hip** ratio WHR (cm).

3.5.2.3. Physical Activity

Physical activity was evaluated using Baecke's Habitual PA Questionnaire, adapted for the University population by (Florindo et al., 2006). The questionnaire is easy to apply and understandable, consisting of 8 questions about habitual physical activity. The first question contains six more questions. Question one includes (*Do you practice or have practiced sport or physical exercise in the last 12 months --- What sport or physical exercise do you practice or have practiced most often? How many hours per week? How many months a year? If you do or have done a second sport or exercise, which type? – how many hours per week? How many months a year?* Other questions include (*Compared to others my age, I think my physical activity lasts longer.; During leisure time, I sweat; During leisure time, I practice sport or physical exercise; During leisure time, I watch television; During leisure time, I walk: During leisure time, I ride a bicycle: How many minutes a day do you walk or cycle to and from work, school or shopping?).*

Table 1: Formulas for calculating the scores of the Baecke questionnaire of AFH

Formulas for calculating the scores of the Baecke questionnaire of AFH
Physical exercise at leisure (LE)
Calculation of the first question regarding the practice of sports/physical exercises:
• Intensity (type of modality) = 0.76 for modalities with light energy expenditure or 1.26 for modalities with moderate energy expenditure or 1.76 for modalities with vigorous energy expenditure (determined by the modality type response: energy expenditure of the modality should be checked in Ainsworth's compendium of physical activities13) • Time (hours per week) = 0.5 for less than one hour per week or 1.5 for more than one hour and less than two hours per week or 2.5 for more than two hours and less than three hours per week or 3.5 for more than three and up to four hours per week or 4.5 for more than four hours per week (determined

by the response of hours per week of practice) • Proportion (months per year) = 0.04 for less than one month or 0.17 between one and three months or 0.42 between four and six months or 0.67 between seven and nine months or 0.92 for greater than nine months (determined by the response of months per year of practice)
To calculate the score for this question, the values must be multiplied and added: Mode 1 = (Intensity*Time*Ratio) + Mode 2 = (Intensity*Time*Ratio) **For the final value, a score will be stipulated according to the values obtained in the formula:** 0 (no physical exercise) = 1/between 0.01 to < 4 = 2/between 4 to < 8 = 3/between 8 to < 12 = 4/ÿ 12.00 = 5
The scores of questions two to four will be obtained according to the answers of the Likert scales **Formulas for calculating the scores of the Baecke questionnaire of AFH.** **The final EFL score must be obtained according to the formula specified below:**
EFL score equals question 1 + question 2 + question 3 + question 4 divided by 4.
Physical leisure activities and locomotion (ALL)
The scores of questions five to eight will be obtained according to the answers of the Likert scale. **The final ALL score must be obtained according to the formula specified below:**
All Score equals (6 - question 5) + question 6 + question 7 + question 8 divided by 4.
Total score (ET) = EFL + ALL

3.5.2.4. History of Sports

Participants were also asked about their past and present sport within the scope of a federation, association, or club, namely about the modality practiced, weekly frequency, duration per session, the context of the competition (regional, national and international) and several years of federated practice.

3.5. Statistical Procedures

Data exploration was carried out to identify possible data entry errors and the presence of outliers. The Kolmogorov-Smirnov test was used to study the normality of the distribution of quantitative variables. Descriptive statistics, including mean and standard deviation, were used to characterize the sample of the variables under study. The chi-square test was used to determine the association between ordinal and nominal qualitative variables, the T-student, to study the differences between subjects with and without postural alterations in the spine in the evaluated body composition and physical activity indicators. The multivariate analysis of variance was used to determine the effect of body composition on the diagnosis of postural alteration in the spine, controlling for gender. Analysis of covariance with adjustment for sex was used to determine the effect of physical activity on the diagnosis of postural changes in the spine.

The software used was SPSS version 27.0; the significance level adopted was 5%.

Bibliographic References

Florindo, A. A., Latorre, M. d. R. D. d. O., Santos, E. C. M. d., Negrão, C. E., Azevedo, L. F., & Segurado, A. A. C. (2006). Validity and reliability of the Baecke questionnaire for the evaluation of habitual physical activity among people living with HIV/AIDS. *Cadernos de saúde pública*, *22*, 535-541.

Faul, F., Erdfelder, E., Buchner, A., & Lang, A. G. (2009). Statistical power analyses using G*Power 3.1: tests for correlation and regression analyses. *Behav Res Methods*, *41*(4), 1149-1160. https://doi.org/10.3758/brm.41.4.1149

CHAPTER 4 – ASSOCIATION BETWEEN BODY COMPOSITION, PHYSICAL ACTIVITY PROFILE, AND OCCURRENCE OF KNEE AND FOOT POSTURAL ALTERATIONS

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Article

Association between Body Composition, Physical Activity Profile, and Occurrence of Knee and Foot Postural Alterations among Young Healthy Adults

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Chapter 4. Article 1

Association between Body Composition, Physical Activity Profile, and Occurrence of Knee and Foot Postural Alterations among Young Healthy Adults

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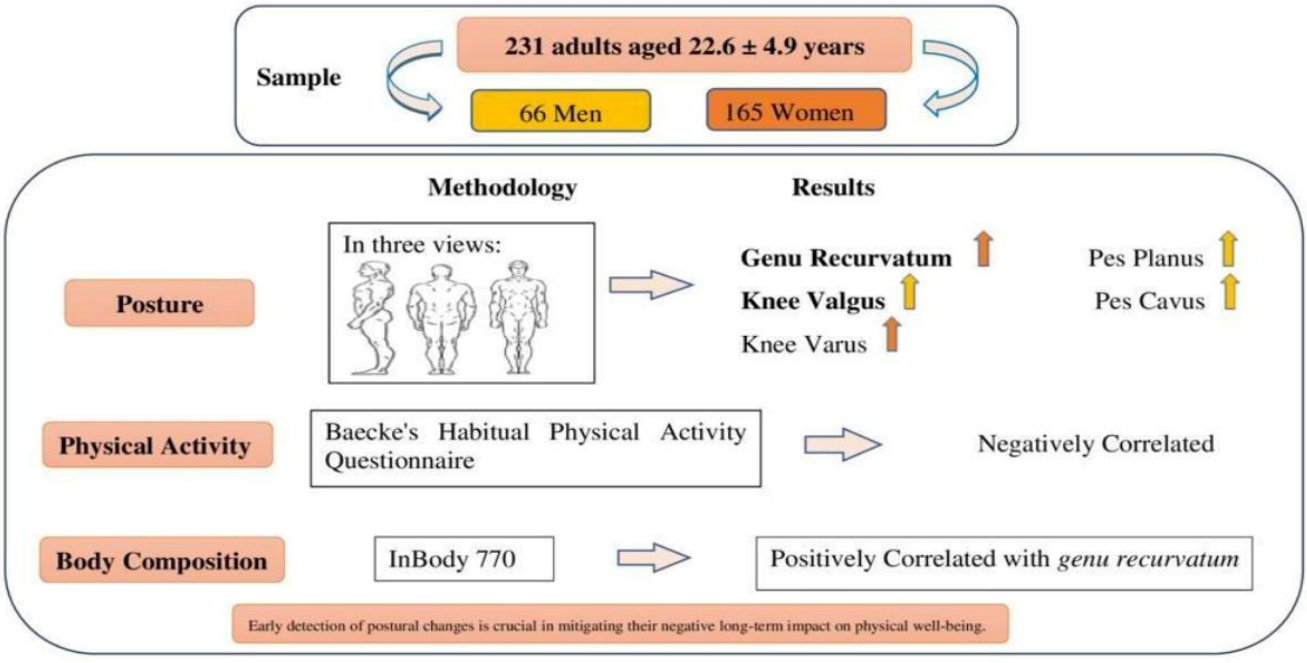
Abstract: Knee and foot deformities refer to structural abnormalities in the knee and foot bones, joints, ligaments, or muscles. Various factors, including genetics, injury, disease, or excessive use, can cause these deformities. These musculoskeletal conditions can significantly impact individuals' quality of life. This study examined foot and knee deformities in 231 young healthy adults (165 men, 66 women) aged 22.6 ± 4.9 years and their association with physical activity and body composition. The postural assessment was performed by two Physiotherapists, with the subject standing in three views: side, anterior, and posterior. Physical activity (Baecke's Habitual Physical Activity Questionnaire) and body composition (InBody 770) were assessed. Results showed that the most common foot deformity was pes planus, while the genu recurvatum was the most common knee deformity among the individuals. Physical activity level was negatively associated with knee and foot deformities. Conversely, body composition differed with the presence of genu recurvatum. These findings present a starting point to understand the occurrence of knee and foot postural alterations according to the individuals' body composition and physical activity profiles, which could support the deployment of tailored interventions among healthy adults. In addition, early detection of postural changes is crucial in mitigating their negative long-term impact on physical well-being.

Keywords: posture; *genu recurvatum*; *pes planus*; *pes cavus*



Introduction

Posture is an attitude or body position maintained at rest, adopted in an activity, or an exact way of supporting the body. It makes quick modifications over time to reduce the body's energy, leading to a rise in muscle stress to maintain proper balance [1]. Posture is maintained by skeletal muscle contraction, coordinated by a series of external stimuli, and through continuous neuromuscular type modifications, representing the body's reaction to the force of gravity [2]. Each individual's distinctive posture may be influenced by several factors, such as ligament elasticity, breathing issues, or bone malformations [3]. Thus, postural changes have been related to unbalanced body components, leading to increased muscle stress to maintain proper balance [4], resulting in discomfort and functional impairment [5].

Studies emphasize that one of the most urgent issues facing contemporary society is the widespread nature of postural abnormalities [6–9], which might eventually lead to inevitable injuries and pain in the corresponding body organ. Foot and knee postures are known to determine how well the lower extremity operates and may contribute to the individual's propensity for recurrent trauma [10,11]. For instance, a study conducted to assess the prevalence of foot pain and deformity among the Danish population reported high correlations between foot pain and foot alterations [12]. Additionally, the previous literature has emphasized the relationship between knee and foot misalignment, with changes in foot alignment before and after knee surgery [13]. Foot postures like pronated foot and flat foot (*pes planus*) are significantly associated with changes in dynamic function, alignment, and medial compartment knee osteoarthritis [14]. Several elements, including lifestyle choices, employment, and the environment, endanger the skeletal system [15]. According to previous studies, decreased physical activity (PA) in overweight and obese individuals contributes to altered lower-limb joint loading compared to normal-weight adults [16]. Differences in walking patterns between overweight and normal-weight individuals are associated with the attempt to increase stability due to impaired balance, minimize external work, and decrease load at the knee [17]. On the other hand, foot problems might be derived from the effects of increased weight on plantar loading, underlining a link between obesity and the development of foot pain [18].

Previous research has identified the most common knee and foot deformities, such as *genu recurvatum*, *genu varum*, *genu varus*, *pes planus*, and *pes cavus*. *Genu Recurvatum* is the position of a tibiofemoral joint in which the range of motion occurs beyond neutral or 0° of extension [19]. In *genu valgus* deformity, ankle joints are spaced apart when knees are in contact with each other in a weight-bearing position [20]. In contrast,

in *genu varus*, the internal condyles of the femur become spaced apart if they are in weight-bearing contact with the media, malleolus of the ankle [20]. The medial longitudinal arch is clinically significant in diseases and the functioning of joints and muscles of the ankle and knee [21]. When the foot's medial arch is disturbed, deformities occur, whereby considerable reduction in the arch causes *pes planus*, whereas the increase in the arch exceeding 18 mm causes *pes cavus* [22].

Meanwhile, the literature has reported that an increase in body mass index (BMI) leads to postural instability in young adults who are obese and non-obese [23–25]. A study on youngsters aged between 7 and 16 years revealed a substantial correlation between age, BMI, and *genu varum* [26]. Weakness in the lower extremities can lead to challenges in everyday activities and regular movements. Enhancing PA levels might be crucial to fighting overweight and obesity, diminishing the risk of injury, and improving the quality of life [27–29]. However, details regarding the relationship between PA, body composition variables, and the prevalence of foot and knee deformities are still lacking among healthy adults. Providing an early diagnosis of postural impairment allows designing targeted interventions that may reduce the detrimental effects of postural deformities [30]. It helps physical education teachers, coaches, and healthcare professionals design appropriate and corrective exercises to improve body alignment. Therefore, the present study aims to (1) determine the occurrence of postural alterations in the knee and foot among healthy adults and (2) compare the PA and body composition profiles between individuals with and without postural alterations in the knee and foot.

2. Methodology

2.1. Sample

This study included 231 adults who were students from the Physical Education and Sports course at the University of Madeira. The sample included 165 men and 66 women aged between 18 and 44 years old (22.5 ± 4.2 years). All participants were healthy and not injured at the time of data collection. The inclusion and exclusion criteria are presented in Figure 1. The optimal sample size was calculated using G*Power [31]. A priori independent samples *t*-test indicated a total sample of 128 participants (64 in each group) to attain 80% power for an effect size of 0.50 at the 0.05 level of significance. All the procedures implemented in the current study received ethical approval from the Scientific Committee of The Faculty of Physical Education and Sports at the University of Madeira (reference: ACTA N.77-12 April 2016). All participants were volunteers, and informed consent was signed before data collection.

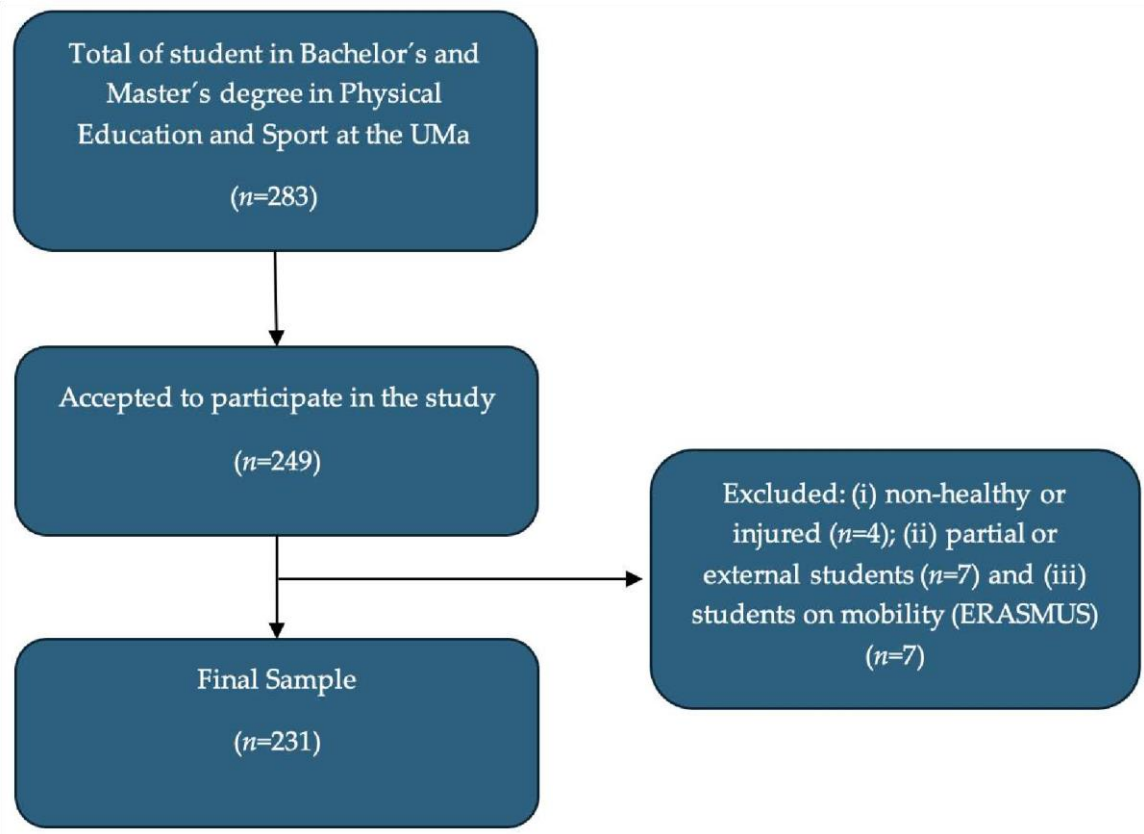


Figure 1. Participants' inclusion and exclusion criteria (*n* = 231).

2.2. General Procedure

2.2.1. Postural Evaluation

The postural evaluation was conducted using the Postural Assessment Table, employing the visual assessment method. The evaluation was carried out by two experienced physiotherapists who were trained in postural assessment techniques. A similar process of postural assessment was employed, as described by [32], in a study involving rhythmic gymnasts and non-trainees to observe the presence of postural alterations. The subjects under observation were assessed while standing in three distinct views: anterior, side, and posterior. Before the assessment, participants were instructed to present themselves barefoot and in light clothing. They assumed a neutral standing position, with specific guidance given regarding their gaze direction (looking forward and fixing their gaze on a point on a wall). Data collection spanned two weeks, during which assessments were conducted for each relevant class. These assessments took place in a dedicated physical performance laboratory between 10 a.m. and 2 p.m. on weekdays. Each evaluation session lasted approximately 40 min, allowing sufficient time for participants to complete consent forms and undergo testing. The decision to conduct assessments during regular working hours was deliberate, aiming to mitigate potential biases related to participants' alertness and concentration levels. Moreover, this approach ensured consistent

conditions for all participants, promoting the overall validity of the research findings. By allocating uniform time slots for assessment sessions, the study sought to enhance the reliability and credibility of the collected data.

a. In the Anterior View

Alignment and symmetry of knee and foot were observed, including alignment of the knee (internal, external rotation, varus, and valgus) and malleolus (symmetry and asymmetry).

b. In the Side View

Alignment and symmetry of knee and foot were observed, including Knees (*genu recurvatum*) and feet (medial longitudinal arch for *pes planus* and *pes cavus*).

c. In the Posterior View

Alignment and symmetry of knee and foot were observed, including popliteal lines (symmetry and asymmetry) and feet (valgus and varus).

2.2.2. Body Composition

Stature was measured to the nearest 0.01 cm using a stadiometer (SECA 213, Hamburg, Germany). Body composition variables were assessed using hand-to-foot bioelectrical impedance analysis (InBody 770, Cerritos, CA, USA). Body mass, body mass index (BMI), fat mass percentage (FM%), total body water (TBW), Intracellular Water, Extracellular Water, protein, minerals, and skeletal muscle mass (SMM), and waist–hip ratio WHR (cm).

2.2.3. Physical Activity

Baecke's Habitual PA questionnaire [33] was used to calculate PA, which includes the following variables:

a) Formal PA

This variable assesses an individual's engagement in formal PA and structured sports. Participants report the activity type, each associated with an intensity factor (0.76 for light, 1.26 for moderate, and 1.76 for vigorous). Time spent per week (0.5 to 4.5 h) and proportion of the year (0.04 to 0.92) are considered. Scores are calculated by multiplying intensity, time, and proportion. The final score, within predefined ranges, reflects overall activity.

b) Informal PA

This variable assesses informal activities in daily life unrelated to structured exercise. Responses to Likert scale questions gauge frequency and intensity. Higher scores indicate greater activity levels.

c) Total Practical History

Scores from Formal PA and Informal PA are combined to measure overall habitual PA. This encompasses both structured and informal activities.

d) Frequency of PA

Assesses planned exercise sessions beyond daily activities. The score typically reflects reported exercise sessions per week.

2.3. Statistical Analysis

Data exploration was carried out to identify possible data entry errors and the presence of outliers. Descriptive statistics were presented as means ± standard deviation. All data were checked for normality using the Kolmogorov–Smirnov test. The independent samples *t*-test was conducted to examine the differences between participants with and without postural changes in quantitative variables with a normal distribution. The software used was SPSS version 27.0 (SPSS Inc., Chicago, IL, USA), and the significance level adopted was 5%.

3. Results

Figure 2 summarizes the occurrence of postural alterations of the knee and foot among the participants based on gender. Overall, *genu recurvatum* was the most frequent postural alteration, representing 54.1%. In contrast, *pes cavus* (4.3%) and *genu varus* (8.7%) were the least frequent postural alterations. A higher proportion of females presented *genu recurvatum*, while *knee valgus* was more prevalent among men. At the same time, the opposite occurs in *knee valgus* (60.4% vs. 39.6%), with the diagnosis occurring in a greater proportion in males than females.

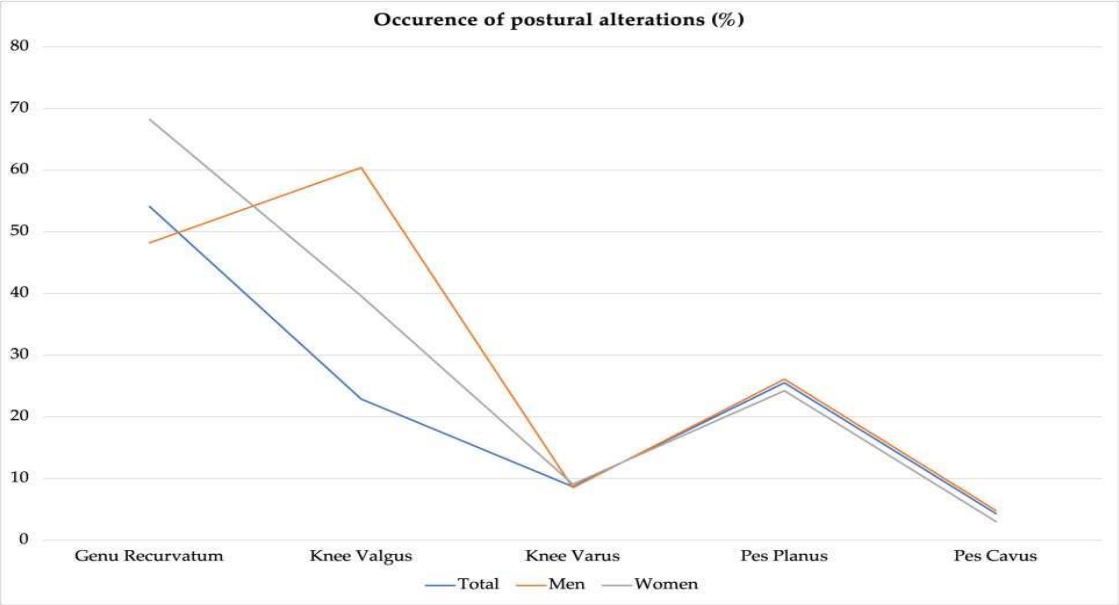


Figure 2. Occurrence of knee and foot postural alterations among the participants.

Table 1 presents the descriptive statistics for body composition variables according to knee postural changes and the comparison results between groups (with and without knee postural changes). Although without statistically significant differences, body mass (M = 70.7 ± 11.7 kg) and BMI (M = 23.4 ± 2.6 kg/m^2) in individuals without *genu recurvatum* alteration were higher than body mass (M = 68.6 ± 12.2 kg) and BMI (M = 23.3 ± 3.2 kg/m^2) in individuals with *genu recurvatum* alteration. Furthermore, WHR (M = 0.86 ± 0.07 cm) and FM (M = 20.8 ± 10.1%) in individuals with *genu recurvatum* alteration were significantly higher than WHR (M = 0.82 ± 0.04 cm) and FM (M = 14.9 ± 7.0%) in individuals without *genu recurvatum* alteration. Stature, TBW, Intracellular Water, Extracellular Water, protein, minerals, and SMM in individuals without *genu recurvatum* alteration were significantly higher in individuals with an alteration ($p < 0.05$).

Body composition, including stature, body mass, TBW, intracellular and extracellular water, protein, FM%, and SMM in individuals without *genu valgus* and *genu varus* was higher than in individuals with *genu valgus* and *genu varus*. The difference was not statistically significant.

Overall, average body mass and BMI were not statistically significant, with a prevalence of *genu recurvatum*. At the same time, other body composition parameters were statistically significant with the occurrence of *genu recurvatum* ($p < 0.05$). Furthermore, Body composition showed no statistically significant relation with *knee valgus* and *varus* prevalence.

Table 2 resumes the descriptive statistics for body composition variables according to foot postural changes and the comparison results between groups (with and without postural changes). Overall, no statistically significant differences were observed between groups regarding body composition on the *pes*

planus deformities. The same trend was seen concerning *pes cavus*, except for stature, which was significantly larger among individuals who showed *pes cavus* postural changes ($p = 0.035$).

Table 1. Descriptive statistics for body composition variables according to knee postural changes and the comparison results between groups (with and without knee postural changes).

	Genu Recurvatum				*Knee Valgus*				*Knee Varus*			
	With	**Without**	**Comparison**		**With**	**Without**	**Comparison**		**With**	**Without**	**Comparison**	
Variable	**Mean ± SD**	**Mean ± SD**	**t**	***p***	**Mean ± SD**	**Mean ± SD**	**t**	***p***	**Mean ± SD**	**Mean ± SD**	**t**	***p***
Stature (cm)	171.21 ± 9.79	174.31 ± 8.44	2.497	0.013 *	171.35 ± 9.97	172.93 ± 9.12	1.052	0.294	172.57± 9.50	172.95 ± 7.56	−0.167	0.867
Body Mass (kg)	68.64 ± 12.23	70.68 ± 11.72	1.222	0.218	68.89 ± 11.53	69.72 ± 12.21	0.679	0.670	67.43 ± 7.84	69.64 ± 12.31	0.168	0.279
BMI (kg/m^2)	23.27 ± 3.15	23.35 ± 2.64	−0.293	0.769	23.43 ± 3.40	23.41 ± 2.79	−0.030	0.976	2340 ± 2.91	23.09 ± 2.16	0.468	0.640
TBW (L)	40.48 ± 8.37	45.18 ± 7.67	2.897	0.005 **	40.21 ± 8.43	43.76 ± 8.14	1.907	0.060	42.71 ± 8.34	45.07 ± 9.47	−0.481	0.632
Intracellular Water (L)	25.56 ± 5.41	28.61 ± 4.96	2.909	0.005 **	25.39 ± 5.43	27.69 ± 5.28	1.911	0.059	27.01 ± 5.40	28.60 ± 6.16	−0.491	0.624
Extracellular Water (L)	14.92 ± 2.91	16.57 ± 2.72	2.863	0.005 **	14.82 ± 3.01	16.07 ± 2.87	1.892	0.062	16.50 ± 3.31	15.71 ± 2.96	−0.459	0.647
Protein (kg)	11.05 ± 2.37	12.37 ± 2.14	2.911	0.004 **	10.97 ± 2.32	11.97 ± 2.29	1.909	0.059	11.67 ± 2.33	12.30 ± 2.64	−0.457	0.649
Minerals (kg)	3.92 ± 0.80	4.34 ± 0.76	2.704	0.008 **	4.22 ± 0.79	3.87 ± 0.79	1.984	0.050 *	4.48 ± 0.99	4.12 ± 0.80	−0.773	0.441
FM (%)	20.78 ± 10.12	14.92 ± 7.01	−3.333	0.001 **	17.05 ± 8.46	20.16 ± 10.75	−1.502	0.136	17.77 ± 5.95	17.91 ± 9.31	0.027	0.979
SMM (kg)	31.32 ± 7.05	35.32 ± 6.47	2.918	0.004 **	31.09 ± 7.07	34.11 ± 6.89	1.921	0.058	33.22 ± 7.04	35.27 ± 8.01	−0.495	0.622
WHR (cm)	0.86 ± 0.07	0.82 ± 0.04	−3.045	0.003 **	0.85 ± 0.06	0.84 ± 0.06	−0.665	0.507	0.85 ± 0.06	0.84 ± 0.06	−0.213	0.832

BMI (body mass index), TBW (total body water), FM (fat mass), SMM (skeletal muscle mass), WHR (waist–hip ratio), SD (standard deviation), * $p \leq 0.05$, ** $p \leq 0.01$.

Table 2. Descriptive statistics for body composition variables according to foot postural changes and the comparison results between groups (with and without postural changes).

	Pes Planus				*Pes Cavus*			
	With	**Without**	**Comparison**		**With**	**Without**	**Comparison**	
Variable	**Mean ± SD**	**Mean ± SD**	**t**	***p***	**Mean ± SD**	**Mean ± SD**	**t**	***p***
Stature (cm)	171.47 ± 9.20	172.94 ± 9.39	1.019	0.309	176.50 ± 5.10	172.36 ± 9.46	−2.372	0.035 *
Body Mass (kg)	69.56 ± 12.27	69.51 ±11.98	−0.022	0.982	72.37 ± 6.55	69.38 ± 12.23	−0.765	0.445
BMI (kg/m²)	23.96 ± 3.31	23.22 ±2.76	0.093	0.108	23.35 ± 1.77	23.42 ± 2.96	−1.613	0.945
TBW (L)	42.99 ± 8.27	42.99 ± 8.27	0.479	0.633	42.65 ± 8.36	45.83 ± 8.08	0.479	0.458
Intracellular Water (L)	26.54 ± 5.58	27.19 ± 5.37	0.488	0.627	26.96 ± 5.41	29.05 ± 5.22	0.488	0.453
Extracellular Water (L)	15.56 ± 3.13	15.80 ± 2.91	0.460	0.647	15.68 ± 2.96	16.78 ± 2.87	0.460	0.471
Protein (kg)	11.76 ± 2.32	11.46 ± 2.39	0.511	0.611	11.65 ± 2.34	12.53 ± 2.25	0.511	0.469
Minerals (kg)	4.15 ± 0.801	4.03 ± 0.82	0.587	0.558	4.11 ± 0.80	4.54 ± 0.84	0.587	0.301
FM (%)	17.53 ± 8.61	19.29 ± 11.25	−0.776	0.439	17.98 ± 9.37	16.25 ± 3.49	−0.776	0.715
SMM (kg)	33.46 ± 7.01	32.61 ± 7.27	0.590	0.627	33.17 ± 7.06	35.90 ± 6.81	0.487	0.450
WHR (cm)	0.85 ± 0.06	0.84 ± 0.06	−0.423	0.673	0.84 ± 0.03	0.84 ± 0.06	−0.423	0.863

BMI (body mass index), FM (fat mass), TBW (total body water), WHR (waist–hip ratio), SMM (skeletal muscle mass), SD (standard deviation), * $p \leq 0.05$.

Table 3 displays the descriptive statistics for PA variables according to knee postural changes and the comparison results between groups (with and without postural changes). The results indicate a significantly larger Score of Formal PA among individuals who presented *knee valgus* compared to those unaffected by this deformity ($p = 0.048$). In addition, a substantially higher Score of Formal PA ($p = 0.003$) and Total Score ($p = 0.004$) was identified in the group with *knee varus* compared to the individuals that did not present this postural change.

Table 3. Descriptive statistics for PA variables according to knee postural changes and the comparison results between groups (with and without postural changes).

	Genu Recurvatum				*Knee Valgus*				*Knee Varus*			
	With	**Without**	**Comparison**		**With**	**Without**	**Comparison**		**With**	**Without**	**Comparison**	
Variable	**Mean ± SD**	**Mean ± SD**	**t**	***p***	**Mean ± SD**	**Mean ± SD**	**t**	***p***	**Mean ± SD**	**Mean ± SD**	**t**	***p***
Score Formal PA	11.93 ± 2.91	12.06 ± 3.10	0.292	0.770	12.70 ± 3.11	11.72 ± 2.91	−1.989	0.048 *	13.62 ± 1.66	11.85 ± 3.03	−3.427	0.003 **
Score Informal PA	2.78 ± 0.58	2.81 ± 0.52	0.283	0.778	2.76 ± 0.57	2.81 ± 0.55	0.582	0.561	2.78 ± 0.67	2.79 ± 0.54	0.132	0.895
Score Total	14.89 ± 3.28	14.73 ± 3.10	0.339	0.735	15.46 ± 3.22	14.54 ± 3.13	−1.730	0.085	16.57 ± 1.93	14.64 ± 3.21	−3.279	0.004 **
Practical History	9.90 ± 5.64	9.34 ± 5.44	−0.656	0.513	10.39 ± 5.11	9.38 ± 5.69	−1.054	0.293	9.13 ± 4.68	9.75 ± 5.66	0.457	0.648
Frequency of PA	8.42 ± 4.57	7.91 ± 3.61	−0.696	0.488	8.89 ± 5.10	7.94 ± 3.79	−1.152	0.251	8.77 ± 4.66	8.16 ± 4.18	−0.494	0.622

PA (physical activity); * $p \leq 0.05$, ** $p \leq 0.01$.

Finally, Table 4 resumes the descriptive statistics for PA variables according to the foot and the comparison results between groups (with and without postural changes). Among the PA variables, a statistically significant difference was only observed in the Frequency of PA for the *pes planus* condition, since the individuals without postural change reported a higher score than the ones affected by postural change ($p = 0.035$).

Table 4. Descriptive statistics for physical activity variables according to foot postural changes ($n = 231$).

	Pes Planus				*Pes Cavus*			
	With	Without	Comparison		With	Without	Comparison	
Variables	Mean ± SD	Mean ± SD	t	*p*	Mean ± SD	Mean ± SD	t	*p*
Score Formal PA	11.32 ± 2.57	12.24 ± 3.10	1.869	0.063	11.44 ± 2.01	12.08 ± 3.03	0.560	0.576
Score Informal PA	2.82 ± 0.55	2.79 ± 0.56	−0.316	0.752	2.79 ± 0.56	2.79 ± 0.38	−0.685	0.494
Score Total	14.13 ± 2.86	15.05 ± 3.26	1.738	0.068	14.36 ± 2.22	14.82 ± 3.21	0.421	0.674
Practical History	7.42 ± 4.47	10.52 ± 5.69	3.393	0.001 *	12.17 ± 5.98	9.52 ± 5.51	−1.401	0.163
Frequency of PA	6.78 ± 3.12	8.69 ± 4.41	2.130	0.035 *	8.64 ± 2.78	8.19 ± 4.29	−0.272	0.786

PA (physical activity); * $p \leq 0.05$.

4. Discussion

This study aimed to evaluate the occurrence of knee and foot postural alterations and the differences in body composition and PA among young healthy adults. The frequency of knee alterations (*genu recurvatum* 54.1%, *knee valgus* 22.9%, and *knee varus* 8.7%) and foot alterations (*pes planus* 25.5% and *pes cavus* 4.3%) in the present study were substantial. Concerning postural alterations for gender, a distinction emerged. *Genu recurvatum* was more common among females (68.2%) compared to males (48.2%), while *knee valgus* exhibited a significantly higher occurrence in males (60.4%) than in females (39.6%).

Indeed, the literature has underlined a heightened occurrence of genu recurvatum among females compared to men [34–36]. In line with these findings, previous authors Penha, et al. [37] reported a comparable prevalence of genu recurvatum (54%) in school-aged children. Conversely, Gh, et al. [38] revealed that 22% of children exhibited genu recurvatum at birth, which showed slight variation with age or gender. The reason for the higher prevalence of genu recurvatum is not well known. However, repetitive and harmful habits that led to posterior capsule laxity could be associated [39], as well as a lack of strength/weakness of the gastrocnemius muscle [40] and the quadriceps muscle, which allows hyperextension of the

knee [41]. In addition, gender differences may arise from factors such as greater knee laxity exhibited by females [42,43], knee geometry variations, and smaller anterior cruciate ligaments [44,45]. Further insights are drawn from another study highlighting the predominance of genu varus as a knee alteration, particularly pronounced among females [46]. In contrast, an alternative investigation by Odding, et al. [47] described varus deformities as more pronounced in males, while valgus deformities exhibited greater prevalence in females. A study conducted on the prevalence of dynamic knee valgus among children indicates 26.3% and 26.9% in the right and left lower limbs, with females exhibiting more knee valgus in the left limb [48]. Concerning foot alterations, prior research showcased the presence of pes planus in a staggering 90.8% of elementary school students [49]. However, among young, healthy individuals, pes planus was 29% in the South Indian population [50]. Notably, the occurrence of pes cavus (4.3%) was consistent with previous studies on the topic that reported a prevalence ranging between 0.2 to 3.7% [49,51–54].

Furthermore, in the current study, *genu recurvatum* condition was statistically significantly related to body composition parameters, particularly %FM and WHR. However, individuals without *genu recurvatum* showed statistically significant higher mean values of TBW, protein, minerals, and SMM. These findings align with the concept that diverse body types give rise to disparities in fat distribution, often manifesting as increased fat mass [55]. The potential connection between body composition and *genu recurvatum* can be attributed to muscle strength imbalances stemming from these varying fat distributions, thus contributing to muscular weaknesses and imbalances [56,57]. In the case of *knee varus* and valgus, no statistically significant connection was established with body composition, given the particular locations and age group in our sample with normal BMI, excluding obesity as a confounding factor. Nevertheless, a study involving individuals aged 11 and 13 years established a significant relationship between weight and *knee varus* and stature and *knee varus* [58]. In addition, the literature presents varying perspectives on the nexus between *genu varus*, *genu valgum*, and obesity. While, Soheilipour, et al. [59] proposed a weaker connection between *genu varus* and obesity, the authors noted a heightened prevalence of *genu valgum* in obese individuals. This observation gains reinforcement from multiple studies collectively indicating an increased occurrence of *genu valgum* [59–62]. Moreover, in the present study, no statistically significant relationship was observed between *pes planus*, *pes cavus*, and BMI, except between *pes cavus* and stature. This contrasts with previous research that asserts a robust and highly significant connection between *pes planus* and BMI [49,63,64].

Concerning PA and postural alterations, no statistical difference was observed between groups with and without *genu recurvatum*; however, formal PA was significantly linked to *knee valgus* and *varus*. The total PA (formal and informal) also differed notably among *knee varus* conditions. Strenuous knee-involved activities can lead to muscle tightness and joint strain, potentially contributing to *knee varus*. This aligns with Lee [65], who emphasized that stress during PA, especially among overweight individuals aiming to lose weight, might precipitate *knee varus* before weight reduction. The reason for *knee valgus* and varus relation with PA is still unknown.

Nonetheless, prevailing research emphasizes how high-intensity athletic performance can induce global and regional muscle fatigue, impairing postural stability [66–68]. Moreover, training parameters affect general fatigue, leading to a strong relationship between the type of exercise, fatigue, and postural deficits [68,69]. Notably, varying postural stability levels were observed in physical education students after short, intense, or prolonged moderate exercise [69]. Evidence suggests that training with poor posture can deteriorate the muscles' proprioceptive feedback mechanism, limiting their ability to correct stance and maintain proper posture due to reduced sensory system input [67,70,71]. Muscle fatigue in stabilizing muscles (such as the gastrocnemius and soleus) misaligns joints and weakens neuromuscular control, contributing to decreased postural stability [66,72]. Furthermore, a statistically significant relationship is found between *pes planus* and practical history and physical exercise frequency. Possible causes include the laxity of soft tissues supporting the arch, including the tibialis posterior muscle, plantar fascia, intrinsic foot muscles, and calcaneonavicular ligaments [73]. A study conducted in Turkey reported weakness of foot plantar flexor group muscles, reduced flexibility of gastrocnemius and soleus muscles, and decreased balance with physical activity in individuals with *pes planus* [74]. In the current study, no statistical significance was found between groups with and without *pes cavus* and physical activity. The lower occurrence could be attributed to congenital causes or neuromuscular disorders like muscular dystrophy and Charcot–Marie–Tooth disease [75,76]. Traumatic injuries can also impact the tarsal bone position and lead to hypertonicity of the longitudinal arches. In *pes cavus*, the peroneus longus and posterior tibialis muscles tend to overpower the peroneus brevis, tibialis anterior, and intrinsic foot muscles, often resulting in plantar flexion due to peroneus longus contracture [77]. Studies have shown that foot postural alterations like *pes planus* and *pes cavus* are associated with an increased risk of various lower extremity injuries compared to individuals with a neutral arch [78–80].

Although these are important findings, this study presents some limitations that should be mentioned. Notably, the study's sample size is relatively modest, suggesting the potential for enhanced robustness by broadening the scope to encompass a more diverse and extensive population. Future efforts could emphasize recruitment across different demographic groups and regions to fortify the generalizability of findings. Moreover, this study's methodology relies on an observational analysis of postures, which, while informative, represents only a partial assessment of the complexities involved. Future investigations could incorporate a multifaceted approach to enhance the depth of research. A further limitation lies in the absence of interventions to address observed postural alterations among the student participants. A valuable avenue for future research lies in implementing interventions tailored to correct identified postural discrepancies and measuring the resultant changes. This longitudinal approach would not only elucidate the potential efficacy of intervention strategies but also contribute to developing evidencebased recommendations for managing and improving posture-related concerns. This study presents a starting point to understand the occurrence of knee and foot postural alterations according to the individuals' body composition and PA profiles, which could support the deployment of tailored interventions among healthy adults.

5. Conclusions

Understanding the prevalence of knee and foot postural alterations holds substantial importance in preventing issues like shin splints, stress fractures, and plantar fasciitis during both physical exertion and routine activities. This study sought to pinpoint key determinants that play a pivotal role in discerning shifts in knee and foot posture while exploring their connections with body composition and physical activity. Ultimately, the investigation highlighted noteworthy factors such as BMI, WHR, and past PA experiences, among others, that could significantly contribute to devising effective strategies for addressing postural alterations in the knee and foot.

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Informed Consent Statement: Informed consent was obtained from all individuals involved in the study.

Data Availability Statement: The data presented in this study are available upon request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Smith, L.K.; Weiss, L.; Lehmkuhl, L.D. *Brunnstrom's Clinical Kinesiology*; FA Davis: Philadelphia, PA, USA, 1996.
2. Barker, V. *Postura, Posizione, Movimento per Potenziare le Prestazioni Sessuali, Rimodellare il Corpo, Ritardare L'invecchiamento, Ridurre L'obesità, Sviluppare le Capacità*; Edizioni Mediterranee: Roma, Italy, 1998.
3. Teixeira, L. *Importância do Movimento Humano na Relação Homem/Trabalho: Aspectos Posturais*; Cepeusp: São Paulo, Brazil, 1996.
4. Bernard, P.; Geraci, M.; Hue, O.; Amato, M.; Seynnes, O.; Lantieri, D. Influence of obesity on postural capacities of teenagers. Preliminary study. *Ann. Readapt. Med. Phys.* **2003**, *46*, 184–190.
5. Detsch, C.; Luz, A.M.H.; Candotti, C.T.; Oliveira, D.S.D.; Lazaron, F.; Guimarães, L.K.; Schimanoski, P. Prevalência de alterações posturais em escolares do ensino médio em uma cidade no Sul do Brasil. *Rev. Panam. De Salud Publica* **2007**, *21*, 231–238. [CrossRef] [PubMed]
6. Andrews, D.M.; Fiedler, K.M.; Weir, P.L.; Callaghan, J.P. The effect of posture category salience on decision times and errors when using observation-based posture assessment methods. *Ergonomics* **2012**, *55*, 1548–1558. [CrossRef] [PubMed]
7. Iedynak, G.; Galamandjuk, L.; Kyselytsia, O.; Nakonechnyi, I.; Hakman, A.; Chopik, O. Special aspects of changes in physical readiness indicators of young men with different somatotypes between 15 and 17 years of age. *J. Phys. Educ. Sport* **2017**, *17*, 2690–2696.
8. Kashuba, V.; Dudko, M. Sovremennye podkhody, metodiki i tekhnologii k formirovaniiu zdorovogo obraza zhizni studentov v processe fizicheskogo vospitaniia [Modern approaches to, methodic and technologies of students' healthy life style formation in process of physical education]. *Fiz. Vikhovannia Sport I Kul'tura Zdorov'ia U Suchasnomu Suspil'stvi* **2015**, *1*, 52–57.
9. Torlakovic, A.; Muftic, M.; Radjo, I.; Talovic, M.; Mahmutovic, I. Evolution of sports-medical team management in the program of posture correction in children. *Mater. Socio-Medica* **2014**, *26*, 104. [CrossRef] [PubMed]
10. Dahle, L.K.; Mueller, M.; Delitto, A.; Diamond, J.E. Visual assessment of foot type and relationship of foot type to lower extremity injury. *J. Orthop. Sports Phys. Ther.* **1991**, *14*, 70–74. [CrossRef] [PubMed]
11. Nigg, B.M.; Cole, G.K.; Nachbauer, W. Effects of arch height of the foot on angular motion of the lower extremities in running. *J. Biomech.* **1993**, *26*, 909–916. [CrossRef]
12. Mølgaard, C.; Lundbye-Christensen, S.; Simonsen, O. High prevalence of foot problems in the Danish population: A survey of causes and associations. *Foot* **2010**, *20*, 7–11. [CrossRef]
13. Chandler, J.T.; Moskal, J.T. Evaluation of knee and hindfoot alignment before and after total knee arthroplasty: A prospective analysis. *J. Arthroplast.* **2004**, *19*, 211–216. [CrossRef]
14. Abourazzak, F.; Kadi, N.; Azzouzi, H.; Lazrak, F.; Najdi, A.; Nejjari, C.; Harzy, T. A positive association between foot posture index and medial compartment knee osteoarthritis in moroccan people. *Open Rheumatol. J.* **2014**, *8*, 96.
15. Sheng, B.; Li, X.; Nussler, A.K.; Zhu, S. The relationship between healthy lifestyles and bone health: A narrative review. *Medicine* **2021**, *100*, e24684. [CrossRef] [PubMed]
16. Browning, R.C. Locomotion mechanics in obese adults and children. *Curr. Obes. Rep.* **2012**, *1*, 152–159. [CrossRef]
17. Kim, D.; Lewis, C.L.; Gill, S.V. Effects of obesity and foot arch height on gait mechanics: A cross-sectional study. *PLoS ONE* **2021**, *16*, e0260398. [CrossRef] [PubMed]
18. Butterworth, P.A.; Urquhart, D.M.; Landorf, K.B.; Wluka, A.E.; Cicuttini, F.M.; Menz, H.B. Foot posture, range of motion and plantar pressure characteristics in obese and non-obese individuals. *Gait Posture* **2015**, *41*, 465–469. [CrossRef]
19. Brownstein, B.; Noyes, F.R.; Mangine, R.E.; Kryger, S. *Physical Therapy of the Knee: Anatomy and Biomechanics*; Mangine, R.E., Ed.; Churchill Livingstone: New York, NY, USA, 1988.
20. Jalalvand, H.; Fatahi, A.; Entezari Khorasani, Z. Comparison of the Kinematic Pattern of Knee Joint Flexion in Healthy and Genu
    Valgum and Genu Varum Children During Jumping. *J. Sport Biomech.* **2021**, *7*, 270–279. [CrossRef]
21. Franco, A.H. Pes cavus and pes planus: Analyses and treatment. *Phys. Ther.* **1987**, *67*, 688–694. [CrossRef]
22. Oatis, C.A. *Kinesiology the Mechanics and Pathomechanics of Human Movement*; Wolters Kluwer: Alphen aan den Rijn, The Netherlands, 2009.
23. Berrigan, F.; Simoneau, M.; Tremblay, A.; Hue, O.; Teasdale, N. Influence of obesity on accurate and rapid arm movement performed from a standing posture. *Int. J. Obes.* **2006**, *30*, 1750–1757. [CrossRef]
24. Hue, O.; Simoneau, M.; Marcotte, J.; Berrigan, F.; Doré, J.; Marceau, P.; Marceau, S.; Tremblay, A.; Teasdale, N. Body weight is a strong predictor of postural stability. *Gait Posture* **2007**, *26*, 32–38. [CrossRef]
25. Maffiuletti, N.; Agosti, F.; Proietti, M.; Riva, D.; Resnik, M.; Lafortuna, C.; Sartorio, A. Postural instability of extremely obese individuals improves after a body weight reduction program entailing specific balance training. *J. Endocrinol. Investig.* **2005**, *28*,
    2–7. [CrossRef]

26. Ghandi, A.R.; Hadi, H.A.; Behruzi, A.R.; Holakooie, A.R. The prevalence of genu-varum in students aged 7–16 in Arak city. *J. Arak Univ. Med. Sci.* **2012**, *15*, 63–68.
27. Bray, G.A. Medical consequences of obesity. *J. Clin. Endocrinol. Metab.* **2004**, *89*, 2583–2589. [CrossRef] [PubMed]
28. Janssen, I.; Katzmarzyk, P.T.; Ross, R. Body mass index, waist circumference, and health risk: Evidence in support of current National Institutes of Health guidelines. *Arch. Intern. Med.* **2002**, *162*, 2074–2079. [CrossRef] [PubMed]
29. Kopelman, P.G. Obesity as a medical problem. *Nature* **2000**, *404*, 635–643. [CrossRef] [PubMed]
30. Tomaszewska, A.; Pawlicka-Lisowska, A. Evaluation of an influence of systematic motor activity on the body posture of young people. *Pol. Merkur. Lek. Organ Pol. Tow. Lek.* **2014**, *36*, 336–340.
31. Faul, F.; Erdfelder, E.; Buchner, A.; Lang, A.-G. Statistical power analyses using G* Power 3.1: Tests for correlation and regression analyses. *Behav. Res. Methods* **2009**, *41*, 1149–1160. [CrossRef] [PubMed]
32. Radaš, J.; Bobic´, T.T. Posture in top-level Croatian rhythmic gymnasts and non-trainees. *Kinesiology* **2011**, *43*, 64–73.
33. Florindo, A.A.; Latorre, M.D.R.D.D.O.; Santos, E.C.M.D.; Negrão, C.E.; Azevedo, L.F.; Segurado, A.A.C. Validity and reliability of the Baecke questionnaire for the evaluation of habitual physical activity among people living with HIV/AIDS. *Cad. De Saúde Pública* **2006**, *22*, 535–541. [CrossRef]
34. Loudon, J.K.; Jenkins, W.; Loudon, K.L. The relationship between static posture and ACL injury in female athletes. *J. Orthop. Sports Phys. Ther.* **1996**, *24*, 91–97. [CrossRef]
35. Nguyen, A.-D.; Shultz, S.J. Sex differences in clinical measures of lower extremity alignment. *J. Orthop. Sports Phys. Ther.* **2007**, *37*, 389–398. [CrossRef]
36. Stanley, H. *Physical Examination of the Spine and Extremities*; Appleton-Century-Crofts: New York, NY, USA, 1976.
37. Penha, P.J.; João, S.M.A.; Casarotto, R.A.; Amino, C.J.; Penteado, D.C. Postural assessment of girls between 7 and 10 years of age. *Clinics* **2005**, *60*, 9–16. [CrossRef]
38. Gh, M.E.; Alilou, A.; Ghafurinia, S.; Fereydounnia, S. Prevalence of faulty posture in children and youth from a rural region in Iran. *Biomed. Hum. Kinet.* **2012**, *4*, 121–126. [CrossRef]
39. Hutchinson, M.R.; Ireland, M.L. Knee injuries in female athletes. *Sports Med.* **1995**, *19*, 288–302. [CrossRef] [PubMed]
40. Kendall, F. *Kendall-McCreary, and Provance PG. Muscles Testing and Function*; Lippincott Williams & Wilkins: Philadelphia, PA, USA, 1993.
41. Stauffer, R.N.; Chao, E.Y.; Györ, A.N. Biomechanical gait analysis of the diseased knee joint. *Clin. Orthop. Relat. Res.* **1977**, *126*, 246–255. [CrossRef]
42. Scerpella, T.A.; Stayer, T.J.; Makhuli, B.Z. Ligamentous laxity and non-contact anterior cruciate ligament tears: A gender-based comparison. *Orthopedics* **2005**, *28*, 656–660. [CrossRef] [PubMed]
43. Shultz, S.J.; Schmitz, R.J.; Nguyen, A.-D.; Chaudhari, A.M.; Padua, D.A.; McLean, S.G.; Sigward, S.M. ACL Research Retreat V: An update on ACL injury risk and prevention, March 25–27, 2010, Greensboro, NC. *J. Athl. Train.* **2010**, *45*, 499–508. [CrossRef]
44. Anderson, A.F.; Dome, D.C.; Gautam, S.; Awh, M.H.; Rennirt, G.W. Correlation of anthropometric measurements, strength, anterior cruciate ligament size, and intercondylar notch characteristics to sex differences in anterior cruciate ligament tear rates. *Am. J. Sports Med.* **2001**, *29*, 58–66. [CrossRef]
45. Chandrashekar, N.; Mansouri, H.; Slauterbeck, J.; Hashemi, J. Sex-based differences in the tensile properties of the human anterior cruciate ligament. *J. Biomech.* **2006**, *39*, 2943–2950. [CrossRef]
46. Maciałczyk-Paprocka, K.; Stawin´ska-Witoszyn´ska, B.; Kotwicki, T.; Sowin´ska, A.; Krzyzaniak, A.; Walkowiak, J.; Krzywin´ska-¨ Wiewiorowska, M. Prevalence of incorrect body posture in children and adolescents with overweight and obesity. *Eur. J. Pediatr.* **2017**, *176*, 563–572. [CrossRef]
47. Odding, E.; Valkenburg, H.; Algra, D.; Vandenouweland, F.; Grobbee, D.; Hofman, A. The association of abnormalities on physical examination of the hip and knee with locomotor disability in the Rotterdam Study. *Rheumatology* **1996**, *35*, 884–890. [CrossRef]
48. Sanchis, G.J.B.; Lopes, J.M.; de Assis, S.J.C.; Catão, R.L.A.; Santos, T.R.T.; Roncalli, A.G.D.C.O. Dynamic knee valgus prevalence in children and its association with pain intensity, foot mobility, and sex—A cross-sectional study. *Heliyon* **2022**, *8*, e10984. [CrossRef]
49. Ganeb, S.S.; Egaila, S.E.-S.; Younis, A.A.; El-Aziz, A.M.A.; Hashaad, N.I. Prevalence of lower limb deformities among primary school students. *Egypt. Rheumatol. Rehabil.* **2021**, *48*, 1–7. [CrossRef]
50. Azhagiri, R.; Malar, A.; Hemapriya, J.; Sumathi, G. The cause and frequency of PES Planus (Flat Foot) problems among young adults. *Asian J. Med. Sci.* **2021**, *12*, 107.
51. Kharbuja, R.; Dhungel, S. Prevalence of Pes Cavus and Pes Planus Among School Going Children of Bhaktapur District, Nepal. *Nepal. Med. Coll. J.* **2017**, *19*, 9–12.

52. Bafor, A.; Chibuzom, C. Foot and ankle abnormalities among a cohort of Nigerian school children: An epidemiological study. *Int. Orthop.* **2020**, *44*, 1169–1175. [CrossRef] [PubMed]
53. Chou, L.-W.; Chen, F.-F.; Lo, S.-F.; Yang, P.-Y.; Meng, N.-H.; Lin, C.-L.; Liao, F.-Y.; Kao, M.-J. The prevalence of four common pathomechanical foot deformities in primary school students in Taichung county. *Mid Taiwan J. Med.* **2009**, *14*, 1–9.
54. Kordi, Y.A. The evaluation and prevalence of foot problems among iranian students using "alfoot" company scanner. *Health Sci. J.* **2014**, *8*, 393.
55. St-Onge, M.-P. Relationship between body composition changes and changes in physical function and metabolic risk factors in aging. *Curr. Opin. Clin. Nutr. Metab. Care* **2005**, *8*, 523–528. [CrossRef]
56. Loudon, J.K.; Goist, H.L.; Loudon, K.L. Genu recurvatum syndrome. *J. Orthop. Sports Phys. Ther.* **1998**, *27*, 361–367. [CrossRef]
57. Ahn, S.-H.; Kwon, O.-Y.; Hwang, U.-J.; Jung, S.-H.; Kim, H.-A.; Kim, J.-H. The association between genu recurvatum angle and the strength of the hip and knee muscles in standing workers. *Work* **2020**, *66*, 173–181. [CrossRef]
58. Lasjouri, G.; Mirzaei, B. The prevalence of postural deformities in pupils aged 11–13 and their relationship with age, height and weight factors. *Res. Sport Sci.* **2005**, *3*, 123–133.
59. Soheilipour, F.; Pazouki, A.; Mazaherinezhad, A.; Yagoubzadeh, K.; Dadgostar, H.; Rouhani, F. The prevalence of genu varum and genu valgum in overweight and obese patients: Assessing the relationship between body mass index and knee angular deformities. *Acta Bio Medica Atenei Parm.* **2020**, *91*, e2020121.
60. Ciaccia, M.C.C.; Pinto, C.N.; Golfieri, F.d.C.; Machado, T.F.; Lozano, L.L.; Silva, J.M.S.; Rullo, V.E.V. Prevalence of genu valgum in public elementary schools in the city of Santos (SP), Brazil. *Rev. Paul. De Pediatr.* **2017**, *35*, 443–447. [CrossRef] [PubMed]
61. Shapouri, J.; Aghaali, M.; Aghaei, M.; Iranikhah, A.; Ahmadi, R.; Hovsepian, S. Prevalence of lower extremities' postural deformities in overweight and normal weight school children. *Iran. J. Pediatr.* **2019**, *29*, 6. [CrossRef]
62. Taylor, E.D.; Theim, K.R.; Mirch, M.C.; Ghorbani, S.; Tanofsky-Kraff, M.; Adler-Wailes, D.C.; Brady, S.; Reynolds, J.C.; Calis, K.A.; Yanovski, J.A. Orthopedic complications of overweight in children and adolescents. *Pediatrics* **2006**, *117*, 2167–2174. [CrossRef] [PubMed]
63. Chen, J.-P.; Chung, M.-J.; Wang, M.-J. Flatfoot prevalence and foot dimensions of 5- to 13-year-old children in Taiwan. *Foot Ankle Int.* **2009**, *30*, 326–332. [CrossRef] [PubMed]
64. Suciati, T.; Adnindya, M.R.; Septadina, I.S.; Pratiwi, P.P. Correlation between flat feet and body mass index in primary school students. In *Journal of Physics: Conference Series*; IOP Publishing: Bristol, UK, 2019; p. 012063.
65. Lee, J. Comparisons of incidence of spinal and lower extremity deformities according to the physical characteristics between sports major and nonmajor college students. *J. Exerc. Rehabil.* **2017**, *13*, 240. [CrossRef] [PubMed]
66. Gribble, P.A.; Hertel, J. Effect of lower-extremity muscle fatigue on postural control. *Arch. Phys. Med. Rehabil.* **2004**, *85*, 589–592. [CrossRef] [PubMed]
67. Cetin, N.; Bayramoglu, M.; Aytar, A.; Surenkok, O.; Yemisci, O.U. Effects of lower-extremity and trunk muscle fatigue on balance. *Open Sports Med. J.* **2008**, *2*, 16–22. [CrossRef]
68. Susco, T.M.; McLeod, T.C.V.; Gansneder, B.M.; Shultz, S.J. Balance recovers within 20 minutes after exertion as measured by the balance error scoring system. *J. Athl. Train.* **2004**, *39*, 241.
69. Zemková, E.; Hamar, D. Postural Sway Response to Exercise: The Effect of Intensity and Duration. *Int. J. Appl. Sports Sci.* **2005**, *17*, 1.
70. Simoneau, M.; Bégin, F.; Teasdale, N. The effects of moderate fatigue on dynamic balance control and attentional demands. *J. Neuroeng. Rehabil.* **2006**, *3*, 1–9. [CrossRef] [PubMed]
71. Vuillerme, N.; Anziani, B.; Rougier, P. Trunk extensor muscles fatigue affects undisturbed postural control in young healthy adults. *Clin. Biomech.* **2007**, *22*, 489–494. [CrossRef] [PubMed]
72. Yaggie, J.; Armstrong, W.J. Effects of lower extremity fatigue on indices of balance. *J. Sport Rehabil.* **2004**, *13*, 312–322. [CrossRef] 73.Deland, J.T. The adult acquired flatfoot and spring ligament complex: Pathology and implications for treatment. *Foot Ankle Clin.* **2001**, *6*, 129–135. [CrossRef]
74. Kızılcı, H.; Erbahçeci, F. Pes planus olan ve olmayan erkeklerde fiziksel uygunlugˇun degˇerlendirilmesi. *Fiz. Rehabil.* **2016**, *27*, 25–33. [CrossRef]
75. Aleander, I.J.; Johnson, K.A. Assessment and management of pes cavus in Charcot-Marie-tooth disease. *Clin. Orthop. Relat. Res.*
1989, *246*, 273–281.
76. Sabir, M.; Lyttle, D. Pathogenesis of pes cavus in Charcot-Marie-Tooth disease. *Clin. Orthop. Relat. Res.* **1983**, *175*, 173–178. [CrossRef]
77. Babu, D.; Bordoni, B. Anatomy, bony pelvis and lower limb, medial longitudinal arch of the foot. In *StatPearls [Internet]*; StatPearls Publishing: Treasure Island, FL, USA, 2021.

78. S¸ahin, F.N.; Ceylan, L.; Küçük, H.; Ceylan, T.; Arıkan, G.; Yigˇit, S.; Sars¸ık, D.Ç.; Güler, Ö. Examining the Relationship between Pes Planus Degree, Balance and Jump Performances in Athletes. *Int. J. Environ. Res. Public Health* **2022**, *19*, 11602. [CrossRef]
79. Zhao, X.; Tsujimoto, T.; Kim, B.; Tanaka, K. Association of arch height with ankle muscle strength and physical performance in adult men. *Biol. Sport* **2017**, *34*, 119–126. [CrossRef]
80. Neal, B.S.; Griffiths, I.B.; Dowling, G.J.; Murley, G.S.; Munteanu, S.E.; Franettovich Smith, M.M.; Collins, N.J.; Barton, C.J. Foot posture as a risk factor for lower limb overuse injury: A systematic review and meta-analysis. *J. Foot Ankle Res.* **2014**, *7*, 1–13. [CrossRef]

CHAPTER 5 – Postural Alterations in the Spine and their Relationship with Body Composition and Physical Activity

Chapter 5. Article 2

Submitted to Gait and Posture Journal.

Postural alterations in the Spine and their relationship with body composition and Physical activity

Abstract

As we advance into adulthood, lifestyle changes lead to postural impairments that might impact an individual's quality of life in the present and future. This study analyzed spinal alterations and their association with body composition and physical activity (PA) levels among healthy adults. Two hundred and thirty-one participants (165 men and 66 women), aged 22.64±4.86 years, were analyzed for spinal alterations by two Physiotherapists, with the subject standing in three views: side, anterior, and posterior. Baecke's Habitual PA questionnaire and Inbody770 assessed physical activity and body composition, respectively. Results showed that the most common spinal alteration was *scoliosis* (56.7%), followed by *kyphosis* (53.2%) and *lordosis* (14.3%), being more prevalent in males than females. PA profile indicated a statistically significant relationship with *lordosis*. In comparison, *scoliosis* was positively associated with height and weight. These findings highlight the importance of evaluating spinal alterations for early detection and intervention to reduce other negative impacts on the spine and other body parts.

Keywords: *Scoliosis*, *Kyphosis*, *Lordosis*, Body Mass Index (BMI), Spinal Cord.

Spinal Postural Alterations, Body Composition, and Physical Activity

Methodology

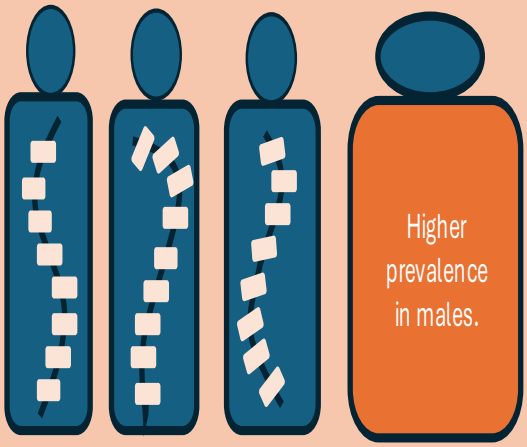
- Participants (n=231); average age 22.64±4.86 years.

n = 66 ♀ vs ♂ n = 165

- Assessment Tools:

Postural evaluation
Baecke's PA questionnaire
Inbody770 for body composition

Results



Scoliosis Kyphosis Lordosis
(56.7%) (53.2%) (14.3%)

Higher prevalence in males.

Lordosis associated with Physical activity.

Scoliosis related to height and weight.

Early detection and intervention are crucial to prevent further negative impacts on spinal health

Introduction

The spine is a fundamental component of posture. It consists of several interconnected, layered, and mobile bones amid one another, forming a rigid column guarding the spinal cord and serving as an axis for the rest of the skeleton [1]. A balanced spine requires a coordinated action of all forces, including passive and active structures and neural control [2]. Changes in spinal alignment occur when spinal curvatures are continuously accentuated [3]. According to the literature, these changes might affect the individuals' quality of life, including problems related to intervertebral discs and various degenerative diseases [4] such as muscle tension, herniated discs, pinched nerves, depressed mood, stress, gastrointestinal problems, breathing problems, back and neck pain, shoulder pain, and headaches [5-7].

In addition, normal musculoskeletal development with excess fat mass and increased body mass index (BMI) has been associated with plastic changes in muscles, bones, and other structures that are maintained throughout the lifespan [8-11]. Therefore, physical activity (PA) is crucial in preventing excess detrimental effects of fat mass and increased BMI.

Previous literature on this topic has pointed out that height and weight presumably control the gravitational pull on the spine and pelvis [12]. Thus, poor postures adopted in daily routines can lead to changes in body structures over time, including shortening or lengthening of ligaments or muscles [13]. For these reasons, postural analysis is vital for clinical assessments in rehabilitation and physical medicine [14]. Examining the relationship between postural control, body composition, and physical activity (PA) might enhance the development of effective treatment plans for the most frequent postural alterations, such as *kyphosis*, scoliosis, and lumbar *lordosis*.

Kyphosis is an exaggerated concave curvature (Cobb angle is >40°) of the thoracic spine [15-18], characterized by anterior tipping, protraction, and downward rotation of the scapula with increased cervical *lordosis* and upper thoracic *kyphosis* [19-22]. The causes of postural *kyphosis* are multifactorial; however, it is often associated with shoulder malalignment and muscular imbalance in the surrounding joints [23, 24]. Muscle tightness of the upper trapezius and pectoralis muscles and weakness of the lower trapezius and cervical flexors characterize hyperkyphotic muscular imbalance [24], sometimes accompanied by enhanced shoulder pain [24-26]. Several studies frequently associate *kyphosis* with decreased outdoor activities [27, 28] and increased functional limitations [27, 29-34]. Habitual kyphotic posture might lead to thoracic outlet syndrome and shoulder instability due to a forward shoulder

position [35, 36] and shoulder impingement due to compression of the subacromial space due to the anterior tilt of the scapula [23, 37].

Scoliosis is a lateral curvature of the spine, with rotation of the vertebrae within the curvature and deviation from the usual vertical line [38]. The causes of *scoliosis* vary and are broadly classified as congenital, neuromuscular, syndromic, idiopathic, and spinal curvature [38]. Right-handed individuals typically present with a mild left thoracolumbar C-curvature or a mild right thoracic and left lumbar S-curvature. Postural and functional *scoliosis* causes non-structural and reversible changes that can be corrected with positional corrections such as supine positioning, lateral and forward flexion exercises, and pelvic alignment through leg length discrepancy correction and muscle contractions [3]. The most common causes of nonstructural *scoliosis* are habitual or asymmetrical postures, muscle defenses against painful stimuli in the back, and a structural or functional leg length discrepancy [3].

A lordotic posture is an increase in lumbar *lordosis*, lumbosacral angle, anterior pelvic tilt, and hip flexion [39]. Spinal biomechanics are altered with increased lumbar *lordosis* due to increased facet loading and shear forces at the lumbosacral junction, resulting in misalignment [40-42]. Imbalances in muscle performance possibly related to *lordosis* include stretched and weak abdominal muscles, including the rectus abdominis, internal and external obliques, and transversus abdominis. Several studies have found a significant relationship between lumbar *lordosis* and BMI [43-45] and a slight correlation between lumbar *lordosis* and waist circumference, but not with a waist-to-hip ratio [46]. Reduced physical function or spending much time sitting contributes significantly to lumbar *lordosis*.

As people age, they acquire habits such as altered gait cycles, everyday sitting and standing posture, and abnormal work ergonomics, which increase the likelihood of developing poor posture [47]. Despite attempts to educate people about the effects of poor posture, this remains a significant health concern [48], mainly affecting the adult population [49]. Early screening and diagnosis are crucial to provide adjusted rehabilitation programs and to prevent long-term health problems associated with posture. Therefore, the present study's aims are twofold: (1) to assess the prevalence of postural problems among healthy adults and (2) to explore the relationship between postural problems, body composition, and PA levels.

Methodology

Sample

This study encompassed a sample of 231 adults (165 males and 66 females), with a mean age of 22.64 ± 4.86 years, who were enrolled in the Physical Education and Sports Program at the University of Madeira. All participants were in good health, free from injuries, and had no diagnosed congenital spinal deformities at the time of data collection.

General Procedure

The study was presented to the participants and their signatures were taken on the informed consent form. The study obtained ethical approval from the Scientific Committee of the Department of Physical Education and Sport (ATA 77, April 12, 2016) and respects the guidelines of the Declaration of Helsinki. The assessments took place in a single session lasting approximately 40 minutes. The assessment of postural changes was carried out by experienced physiotherapists. The remaining assessments were carried out by Physical Education graduates who had previously undergone training in using the Inbody and applying the questionnaires.

Postural evaluation

The postural evaluation was performed using a Postural Assessment Table, and the visual evaluation method was performed by two experienced physiotherapists trained in postural assessment techniques. This process mirrored the methodology described by Radaš and Bobić (2011) in a study comparing rhythmic gymnasts and non-athletes to detect postural deviations. Participants were evaluated in three distinct standing positions: anterior, side, and posterior views. Before the assessment, participants were instructed to be barefoot and wear light clothing. They stood in a neutral position, with their gaze fixed on a designated wall point. The data collection occurred over a two-week period, with assessments conducted in a physical performance laboratory from 10 a.m. to 2 p.m. on weekdays. Conducting the evaluations during standard working hours was intended to reduce potential biases related to participants' alertness and concentration, ensuring consistent conditions. This scheduling aimed to enhance the validity and reliability of the research findings by maintaining uniform assessment conditions for all participants.

In the Anterior View

For the spine, alignment of the iliac crest was observed and palpated to see the symmetry of the anterior superior iliac spine, which helps indicate pelvic tilting and spinal deviation.

In the Side View

Cervical, thoracic, lumbar, and sacral regions were observed for spinal curvatures. Examination of forward and backward protrusion of the head, shoulder anteriorization and posteriorization, increased *kyphosis* curve of the thoracic spine, and increased lumbar *lordosis* were observed.

In the Posterior View

Assessment in posterior view included shoulder (alignment– elevation, and depression), shoulder blades (elevation and depression), vertical alignment of spine observed and palpated for *scoliosis* or rotation of vertebrae.

Body Composition

Body composition parameters were measured through InBody770 (Cerritos, CA, USA), which uses bioelectrical impedance analysis to measure body composition (body mass index, fat mass percentage, total body water, intracellular water, extracellular water, protein, minerals, and skeletal muscle mass, and waist-hip ratio). The participants were barefoot and wearing light sportswear without any metal accessories. They were asked to be fasting (at least 8 hours) without consuming caffeine, alcohol, caloric drinks, or tobacco. They were also asked to refrain from vigorous physical exercise in the 24 hours before the assessment. Height was assessed by a stadiometer (SECA 213, Hamburg, Germany), recording it on a millimeter.

Physical Activity

Baecke's Habitual PA questionnaire was used to calculate physical activity, adapted for the university population in previous literature (Florindo & Latorre, 2003); originally developed by Baecke et al. (1982). The questionnaire was used to assess the following variables:

Formal physical activity:

This variable evaluates an individual's participation in formal physical activities and structured sports. Participants specify the type of activity, which is assigned an intensity factor (0.76 for light, 1.26 for moderate, and 1.76 for vigorous). Weekly duration (0.5 to 4.5 hours)

and yearly proportion (0.04 to 0.92) are also factored in. Scores are derived by multiplying intensity, duration, and proportion. The final score, categorized into predefined ranges, indicates the overall level of activity.

Informal physical activity:

This variable evaluates informal daily activities that are not necessarily related to structured exercise. Responses to Likert scale questions measure the frequency and intensity of these activities, with higher scores indicating greater levels of activity.

Total practical history:

The total habitual activity score is derived by integrating the scores from the formal and informal activity sections, providing a holistic measure of an individual's physical activity levels.

Frequency of physical exercise:

This variable evaluates the frequency of deliberately scheduled exercise sessions or workouts, distinct from routine daily activities. The reported number of exercise sessions per week typically determines the score.

Statistical Procedure

Descriptive statistics were presented as means and standard deviation. All data were checked for normality using the Kolmogorov-Smirnov. The chi-square test was used to determine the association between qualitative ordinal variables (for example, sex and diagnosis). The one-sample t-test study was conducted to examine the differences between subjects with and without postural alterations in the spine in the selected body composition parameters and PA indicators.

Multivariate analysis of variance was used to determine the differences between without and with postural alterations after controlling for age and sex in body composition parameters. To examine the difference between the diagnosis of postural changes in the spine in physical activity, we analyzed covariance after controlling for age and sex, school social support, and participation in extracurricular physical activity.

All analyses were performed using IBM SPSS Statistics software 27.0 (SPSS Inc., Chicago, IL, USA). The significance level was set at 5%.

Results

Table 1 summarizes the prevalence of postural alterations of the spine and the results of the comparison by gender. Among all participants, *scoliosis* (56.7%) and *kyphosis* (53.2%) were the most prevalent conditions. The analysis by gender showed a significantly higher prevalence in men for *scoliosis* (p=0.013) and *kyphosis* (p=0.037) compared to women. Although a higher prevalence was also observed in men for *lordosis* (p=0.154), the differences were not statistically significant.

There are no significant differences in the average age between participants with and without postural changes in the evaluated spine ($p \geq 0.05$).

Table 1. Prevalence of postural alterations of the spine in the sample (n=231)

	Total (n=231)	**Men (n=165)**	**Women (n=66)**	**p**
Scoliosis (%)	56.7%	61.8%	43.9%	0.013
Kyphosis (%)	53.2%	57.8%	42.4%	0.037
Lordosis (%)	14.3%	14.4%	9.1%	0.154

Table 2 presents descriptive data and results comparing body composition variables between individuals with and without postural alterations. Concerning *scoliosis*, significant statistical differences were seen for height ($p < 0.01$) and weight ($p < 0.05$), with individuals with postural alteration being taller and heavier than their peers. Participants with *scoliosis* presented lower mean values in BMI and FM%; however, the differences were not statistically significant. The same trend was observed for *kyphosis* and *lordosis* regarding height and weight, although the differences were only substantial in *kyphosis* diagnosis ($p < 0.05$).

However, considering that the prevalence of these two postural alterations is higher in males and that body composition is equally influenced by gender, a multivariate ANOVA was performed with adjustment for gender. This statistical procedure was intended to determine the effect of body composition on the diagnosis of postural changes, controlling the possible influence of sex, noting that none of the body composition indicators evaluated impact the diagnosis of postural changes ($p > 0.05$). The differences detected between participants with and without *scoliosis* and with and without *kyphosis* are expected to be sustained by sex.

Among the participants with and without a diagnosis of *lordosis*, there were no statistically significant differences in any of the body composition indicators evaluated ($p>0.05$).

Table 2. Descriptive statistics for body composition variables according to postural changes (n = 231).

	Scoliosis				*Kyphosis*				*Lordosis*			
	With	Without	Comparison		With	Without	Comparison		With	Without	Comparison	
	Mean ± SD	Mean ± SD	t	*p*	Mean ± SD	Mean ± SD	t	*p*	Mean ± SD	Mean ± SD	t	*p*
Height (cm)	173.71 ± 9.35	169.25 ± 8.89	-3.555	<0.001**	172.45 ± 8.49	171.61 ± 9.54	-2.420	0.016*	173.85 ± 10.31	170.21 ± 8.26	-0.446	0.656
Weight (kg)	70.84 ± 11.92	67.43 ± 11.23	-2.150	0.033*	71.70 ± 10.19	68.96 ± 11.91	-0.491	0.624	72.62 ± 12.22	69.40 ± 10.02	-1.174	0.242
BMI ($kg.m^{-2}$)	23.38 ± 2.87	23.45 ± 3.01	0.181	0.8570	24.6 ± 2.75	23.31 ± 2.95	1.190	0.235	23.92 ± 3.33	23.95 ± 3.08	-1.288	0.199
Total Body Water (L)	43.99 ± 8.63	40.70 ± 7.46	-1.905	0.060	42.59 ± 6.41	42.81 ± 8.60	-1.221	0.225	43.99 ± 8.63	40.70 ± 7.46	0.083	0.934
Intracellular Water (L)	27.82 ± 5.57	25.73 ± 4.86	-1.875	0.064	26.98 ± 4.22	27.06 ± 5.56	-1.245	0.216	27.82 ± 5.39	25.731 ± 4.86	0.048	0.962
Extracellular Water (L)	16.18 ± 2.68	15.46 ± 3.09	-1.952	0.054*	15.61 ± 2.21	15.74 ± 3.06	-1.172	0.244	16.16 ± 3.07	14.97 ± 2.61	0.146	0.884
Protein (kg)	12.06 ± 2.13	11.48 ± 2.43	-1.890	0.062	11.66 ± 1.82	11.70 ± 2.40	-1.204	0.231	12.03 ± 2.39	11.12 ± 2.12	0.055	0.957
Minerals (kg)	4.26 ± 0.76	4.05 ± 0.822	-1.891	0.062	4.14 ± 0.58	4.12 ± 0.833	-1.232	0.221	4.24 ± 0.84	3.93 ± 0.700	-0.072	0.943
FM (%)	16.80 ± 9.57	18.55 ± 8.99	1.377	0.172	20.77 ± 8.23	17.51 ± 9.30	0.906	0.367	16.94 ± 8.51	19.58 ± 10.19	-1.152	0.252
SMM (kg)	34.43 ± 6.44	32.61 ± 7.32	-1.872	0.064	33.18 ± 5.49	33.29 ± 7.25	-1.241	0.218	34.28 ± 7.27	31.56 ± 6.35	0.055	0.956
Waist-to-hip ratio (cm)	0.85 ± 0.07	0.84 ± 0.06	0.568	0.571	0.87 ± 0.06	0.84 ± 0.06	-0.464	0.643	0.84 ± 0.55	0.85 ± 0.07	-1.374	0.173

BMI (body mass index), FM (fat mass), SMM (skeletal muscle mass), SD (standard deviation), * $p \leq 0.05$, ** $p \leq 0.01$

Figures 1, 2, and 3 illustrate the PA profiles according to postural alteration diagnosis. Overall, superior mean PA levels were observed for participants with postural alterations compared to their peers. In the case of *kyphosis*, the differences between groups were significant ($p < 0.05$).

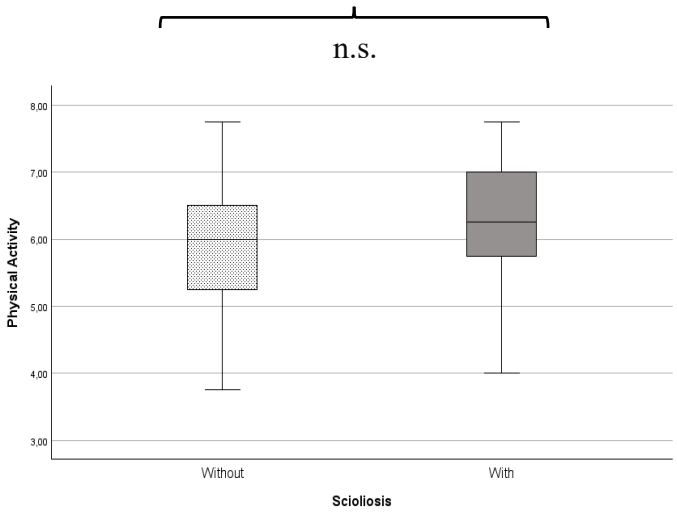
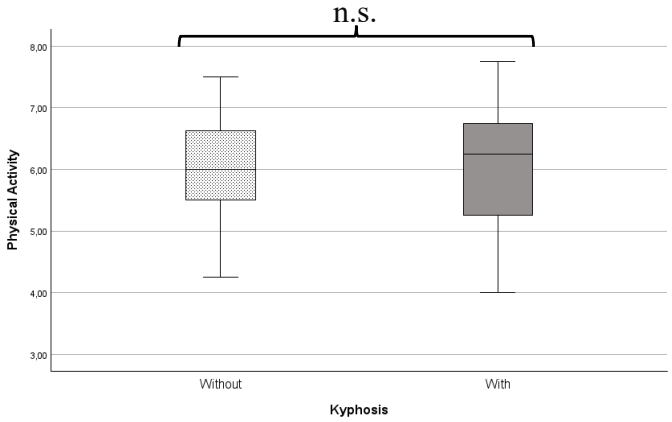
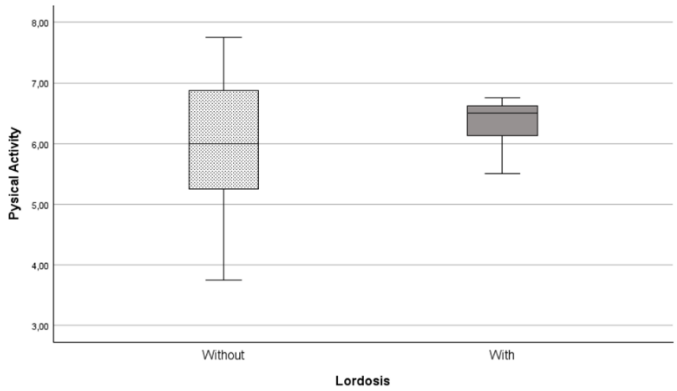


Figure 1. PA levels among participants with and without *scoliosis*.



n.s. - Not significant

Figure 2. PA levels among participants with and without *kyphosis*.



* p<0.05

Figure 3. PA levels among participants with and without *lordosis*

Analyzing the sport's history, it can be seen that participants diagnosed with *scoliosis* (7.83±5.88 vs. 7.61±7.12), *kyphosis* (7.98±5.86 vs. 7.50±6.91), and *lordosis* (7.75±6.23 vs. 7.69±7.36), have on average a higher number of years of federated practice, although in none of the cases is statistically significant (p>0.05). The same thing happened regarding the weekly frequency of exercise practice, the participants diagnosed with *scoliosis* (6.51±4.93 vs 5.43±5.35), *kyphosis* (6.814±5.39 vs 5.33±4.75), and *lordosis* (5.87±5.12 vs 6.11±5.13), report higher values on average.

Discussion

This study aimed to assess the prevalence of postural alterations among healthy adults and explore the relationship between postural alterations, body composition, and PA levels. Overall, *scoliosis* (56.7%) was the most common postural alteration observed, followed by kyphosis (53.2%) and *lordosis* (14.3%). The results of the present study indicate a higher prevalence level of postural alteration in men than in women. The analysis between body composition and postural changes showed that individuals with postural alteration diagnoses were taller, heavier, and presented superior scores of PA levels than their peers. These deviations in posture, including *scoliosis*, *kyphosis*, and *lordosis* in adults, often arise due to improper sitting posture, body misalignment, slouching, poor ergonomic design, and effects of gravity [3].

Parallel to the present study, Anna, Olena [53] reported a comparable finding of *scoliosis* (47.3%) among 182 physical education students at Yuriy Fedkovych Chernivtsi National University. However, the authors reported different results, indicating that *scoliosis*

and kypho*scoliosis* were not widespread postural alterations, with rates of only 30.76% and 12.83%, respectively [54]. This discrepancy with the current study might be attributed to age and a smaller sample size of 102 students. Another study conducted at the University of Venda, South Africa, found that 34% of participants had *kyphosis*, 22% displayed *lordosis*, and 3% had *scoliosis* [55]. These variations in prevalence compared to the current study could be due to differences in demographics, sample characteristics, and sample sizes.

Additionally, there were variations in the severity of postural alterations between genders. This study observed that 61.8%, 57.8%, and 14.4% of males exhibited *scoliosis*, *kyphosis*, and *lordosis*, respectively. Among females, the percentages were 43.9% for *scoliosis*, 42.4% for *kyphosis*, and 9.1% for *lordosis*. Furthermore, when comparing genders, statistically significant differences were found only for *scoliosis* and *kyphosis*, while the difference in *lordosis* was not significant. It is worth considering that these disparities may be due to the more significant proportion of males within the sample and variations in anatomical composition. A previous study conducted by Been, Pessah [56] found no statistically significant gender-based difference in *lordosis*, which aligns with the observations of the current study. Moreover, Malepe, Goon [55] reported a higher prevalence of *kyphosis* in males and *lordosis* in females, with no gender-based difference for *scoliosis*. The occurrence of *lordosis* was attributed to higher gluteal mass in females. Another study conducted on 379 individuals of 20 to 50 years of age reported no statistically significant difference in *lordosis* concerning gender [56], supporting the current study's observations.

The present study demonstrated the intricate relationship between postural changes and various body composition parameters in individuals with different spinal alterations. Notably, a statistically significant relationship was observed between height and weight in individuals with *scoliosis*, indicating a potential link between these two variables in this specific group. However, although they displayed higher values in individuals with *scoliosis*, these differences did not achieve statistical significance when considering other parameters. Moreover, the investigation into individuals with *kyphosis* yielded a distinct result – a significant disparity in height was noted, implying a potential connection between *kyphosis* and height. Conversely, no statistically significant variance in the evaluated body composition parameters was identified when focusing on *lordosis* between individuals with or without this postural change. Intriguingly, a prior study involving South African college students failed to identify a significant correlation between BMI and *kyphosis* and *scoliosis*. Nevertheless, this study did unveil a negative correlation between BMI and *lordosis*, hinting at an increased likelihood of

developing *lordosis* with higher BMI values [55]. Our research, which examined mean BMI values of 23.38±2.87 and 23.45±3.01 with and without postural alterations, determined that the sampled individuals fell within the normal BMI range. This suggests the absence of obesity in the overall sample, potentially elucidating the lack of a statistically significant association between BMI and postural changes. This observation aligns with the findings of Hinman [31] in a study investigating kyphotic posture in different age groups of women, where the BMI values also remained within the normal range. A collective body of research, including studies by [57-60], has established a negative link between higher BMI, increased fat percentage, and compromised postural stability. Furthermore, a recent study examining the impact of postural cueing on head and neck posture and lumbar *lordosis* angles in healthy adults Zhai, Huang [61] did not uncover a significant correlation between BMI and lumbar *lordosis*. Intricacies within the literature are evident, as certain studies have unveiled significant associations between lumbar *lordosis* and BMI [43-45], while others have identified only slight correlations between lumbar *lordosis* and waist circumference but not waist-hip ratio [46]. A potential rationale for the higher proportion of *lordosis* in men might lie in their tendency to accumulate more abdominal fat [62], which shifts their center of gravity in the anteroposterior direction, thereby challenging them to maintain balance [63].

Furthermore, the study suggests a trend toward higher physical activity scores in individuals exhibiting postural alterations. However, we did not find a statistical relationship between *scoliosis* and *kyphosis*. In contrast, a statistically significant connection emerged between physical activity and individuals with and without *lordosis*. A noteworthy aspect is that participants with postural deformities demonstrated more years engaged in federated exercise activities, although this disparity did not reach statistical significance. This observation can be attributed to the potential influence of systematic training and repetitive unilateral exercises on the alignment of spinal curves. [64-67]. The spinal alterations associated with specific sports have been well-documented in previous studies, such as volleyball [68], handball [69], tennis [70], footballers [71], and gymnastics [72]. These sports-specific adaptations often result from the asymmetric nature of movements intrinsic to each sport. For instance, Lichota, Plandowska [73] and Wodecki, Guigui [71] have shown variations in thoracic *kyphosis* and lumbar *lordosis* among athletes in different sports, with soccer players displaying differing patterns compared to gymnasts. Additionally, the postural alterations in individuals with higher rates of physical activity can be explained through the link between postural alterations and specific muscle imbalances. For instance, *lordosis* has been associated

with reduced flexibility and tightening of hamstring muscles [74, 75], shortened iliopsoas muscles [74, 76], and weakened abdominal muscles [77]. These imbalances may arise due to targeted exercises practiced in various sports. Similarly, sports that emphasize poor body alignment may lead to muscle imbalances, such as tight pectoralis minor muscles [20, 22, 78] and weak trapezius and rhomboid muscles, contributing to rounded shoulders in *kyphosis* [20, 48]. The study underscores the importance of monitoring asymmetry in young adults and athletes' training regimens and the implementation of compensatory exercises and stretching routines. This not only aids in injury prevention but also maximizes athletic performance efficiency. By addressing these imbalances, young adults and athletes can optimize their training outcomes and reduce the risk of injury, aligning with the insights highlighted by Vařeková, Vařeka [79] and Krzykała [80].

The current study is accompanied by several noteworthy limitations that warrant consideration. Primarily, the sample size employed is relatively small, thereby advocating for an extension of the research to encompass a diverse population. The expansion would undoubtedly enhance the depth of insights into the prevalence of postural alterations within the adult demographics. In addition, the current study offers valuable preliminary insights. However, a more comprehensive approach involving detailed posture angle measurements could contribute substantially to the body of knowledge. Incorporating metrics such as the lumbar curve angle and Cobb's angle would offer a more nuanced understanding of postural alterations and their implications. An insightful approach could involve analyzing postural alterations in connection with distinct sports or athletic disciplines. This tailored examination would contribute to a refined understanding of sport-specific impacts on posture and offer athletes, coaches, and healthcare professionals' valuable insights into optimizing performance and minimizing postural-related risks.

Conclusion:

The study is pivotal in raising awareness about spinal posture alterations, particularly within the sphere of individuals engaged in physical education. By disseminating knowledge on postural alterations, the research equips them with means to preemptively tackle postural challenges, facilitating early detection, prompt management, and prevention of misalignments. And associated musculoskeletal disorders. It provides insight into the relationship between posture, body composition, and physical activity that helps tailor intervention programs to cater to individualized requirements. Based on research findings, physical education instructors are

poised to develop training regimens that holistically address postural alterations and cultivate favorable body compositions, harnessing physical engagement's full spectrum of benefits.

Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Scientific Committee of The Faculty of Physical Education and Sports at the University of Madeira (reference: ACTA N.77-12 April 2016).

Informed Consent Statement: Informed consent was obtained from all individuals involved in the study.

Data Availability Statement: The data presented in this study are available upon request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

Bibliographic References:

1. Kapandji, A., *Fisiologia articular: Esquemas comentados de mecânica humana.* Ed. Rio de Janeiro: Panamericana, 2000. **3**.
2. Fritz, J.M., R.E. Erhard, and B.F. Hagen, *Segmental instability of the lumbar spine.* Physical therapy, 1998. **78**(8): p. 889-896.
3. Kisner, C., L.A. Colby, and J. Borstad, *Therapeutic exercise: foundations and techniques*. 2017: Fa Davis.
4. Berven, S. and R. Wadhwa, *Sagittal alignment of the lumbar spine.* Neurosurgery Clinics, 2018. **29**(3): p. 331-339.
5. Curone, D., et al., *A real-time and self-calibrating algorithm based on triaxial accelerometer signals for the detection of human posture and activity.* IEEE transactions on information technology in biomedicine, 2010. **14**(4): p. 1098-1105.
6. Yi, W.-J., et al. *Wearable sensor data fusion for remote health assessment and fall detection*. in *IEEE International Conference on Electro/Information Technology*. 2014. IEEE.
7. Zhang, Y., et al. *Continuous functional activity monitoring based on wearable tri-axial accelerometer and gyroscope*. in *2011 5th International Conference on Pervasive Computing Technologies for Healthcare (PervasiveHealth) and Workshops*. 2011. IEEE.
8. Araújo, F. and R. Lucas, *What do we know about the determinants of sagittal standing posture.* OA Musculoskeletal Medicine, 2014. **2**(2): p. 15.
9. Boulay, C., et al., *Sagittal alignment of spine and pelvis regulated by pelvic incidence: standard values and prediction of lordosis.* European Spine Journal, 2006. **15**: p. 415-422.
10. Smith, A., P. O'Sullivan, and L. Straker, *Classification of sagittal thoraco-lumbo-pelvic alignment of the adolescent spine in standing and its relationship to low back pain.* Spine, 2008. **33**(19): p. 2101-2107.
11. Smith, A.J., et al., *Trajectories of childhood body mass index are associated with adolescent sagittal standing posture.* International Journal of pediatric obesity, 2011. **6**(sup3): p. e97-106.
12. Roussouly, P. and J.L. Pinheiro-Franco, *Biomechanical analysis of the spino-pelvic organization and adaptation in pathology.* European Spine Journal, 2011. **20**: p. 609-618.
13. Levangie, P.K. and C.C. Norkin, *Joint structure and function: a comprehensive analysis*. 2011: FA Davis.
14. Zagyapan, R., et al., *The relationship between balance, muscles, and anthropomorphic features in young adults.* Anatomy research international, 2012. **2012**.
15. Fernandez, E.F., *CHAPTER 16 - Kyphosis*, in *Deep Tissue Massage Treatment*, E.F. Fernandez, Editor. 2006, Mosby: Saint Louis. p. 110-117.
16. Jung, S.-h., et al., *Correlation among non-radiological measurements for thoracic kyphosis.* Journal of Musculoskeletal Science and Technology, 2020. **4**(1): p. 1-5.
17. Neumann, D.A., *Kinesiology of the musculoskeletal system-e-book: foundations for rehabilitation*. 2016: Elsevier Health Sciences.
18. Teixeira, F. and G. Carvalho, *Reliability and validity of thoracic kyphosis measurements using flexicurve method.* Brazilian Journal of Physical Therapy, 2007. **11**: p. 199-204.

19. Greenfield, B., *Upper quarter evaluation: structural relationships and independence.* Orthopaedic Physical Therapy (3rd edition). New York: Churchill Livingstone, 2001.
20. Lukasiewicz, A.C., et al., *Comparison of 3-dimensional scapular position and orientation between subjects with and without shoulder impingement.* Journal of Orthopaedic & Sports Physical Therapy, 1999. **29**(10): p. 574-586.
21. Sahrman, S., *Diagnosis and Treatment of Movement Impairment Syndromes: Lecture Outline.* Washington: School of Medicine, Washington University, 1998.
22. Wang, C.-H., et al., *Stretching and strengthening exercises: their effect on three-dimensional scapular kinematics.* Archives of physical medicine and rehabilitation, 1999. **80**(8): p. 923-929.
23. Lee, J.-H., et al., *Predictor variables for forward scapular posture including posterior shoulder tightness.* Journal of Bodywork and Movement Therapies, 2015. **19**(2): p. 253-260.
24. Page, P., C.C. Frank, and R. Lardner, *Assessment and treatment of muscle imbalance: the Janda approach*. 2010: Human kinetics.
25. Grimsby, O. and J. Gray, *Interrelation of the spine to the shoulder girdle.* Physical therapy of the shoulder, 1997. **3**: p. 95-129.
26. Seidi, F., et al., *Comprehensive corrective exercise program improves alignment, muscle activation and movement pattern of men with upper crossed syndrome: randomized controlled trial.* Scientific reports, 2020. **10**(1): p. 20688.
27. Balzini, L., et al., *Clinical characteristics of flexed posture in elderly women.* Journal of the American Geriatrics Society, 2003. **51**(10): p. 1419-1426.
28. Greendale, G.A., et al., *Yoga decreases kyphosis in senior women and men with adult-onset hyperkyphosis: results of a randomized controlled trial.* Journal of the American Geriatrics Society, 2009. **57**(9): p. 1569-1579.
29. Bartynski, W.S., et al., *Severe thoracic kyphosis in the older patient in the absence of vertebral fracture: association of extreme curve with age.* American journal of neuroradiology, 2005. **26**(8): p. 2077-2085.
30. Ettinger, B., et al., *Kyphosis in older women and its relation to back pain, disability and osteopenia: the study of osteoporotic fractures.* Osteoporosis International, 1994. **4**: p. 55-60.
31. Hinman, M.R., *Comparison of thoracic kyphosis and postural stiffness in younger and older women.* The spine journal, 2004. **4**(4): p. 413-417.
32. Kado, D.M., et al., *Hyperkyphotic posture and poor physical functional ability in older community-dwelling men and women: the Rancho Bernardo study.* The Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 2005. **60**(5): p. 633-637.
33. Lindsey, C. and G. MScAH, *Impaired posture.* Geriatric Physical Therapy, 2011: p. 292-315.
34. Osman, A.A.-H., et al., *Aging of the thoracic spine: distinction between wedging in osteoarthritis and fracture in osteoporosis—a cross-sectional and longitudinal study.* Bone, 1994. **15**(4): p. 437-442.
35. Fathollahnejad, K., A. Letafatkar, and M. Hadadnezhad, *The effect of manual therapy and stabilizing exercises on forward head and rounded shoulder postures: a six-week intervention with a one-month follow-up study.* BMC musculoskeletal disorders, 2019. **20**: p. 1-8.
36. Singla, D. and Z. Veqar, *Association between forward head, rounded shoulders, and increased thoracic kyphosis: a review of the literature.* Journal of chiropractic medicine, 2017. **16**(3): p. 220-229.

37. Gumina, S., et al., *Subacromial space in adult patients with thoracic hyperkyphosis and in healthy volunteers.* La Chirurgia degli organi di movimento, 2008. **91**: p. 93-96.
38. Janicki, J.A. and B. Alman, *Scoliosis: Review of diagnosis and treatment.* Paediatrics & Child Health, 2007. **12**(9): p. 771-776.
39. Bullock-Saxton, J., *Normal and abnormal postures in the sagittal plane and their relationship to low back pain.* Physiotherapy Practice, 1988. **4**(2): p. 94-104.
40. Cho, M., et al., *Correlations among sacral angle, lumbar lordosis, lumbar ROM, static and dynamic lumbar stability in college students.* Journal of physical therapy science, 2011. **23**(5): p. 793-795.
41. Ma, S., W. Gong, and H. Ro, *The correlations between lumbar lordosis, L4-5 disc angle, L4-5 disc height, and the lumbosacral angle in L4-5 HNP patients.* Journal of Physical Therapy Science, 2010. **22**(4): p. 391-394.
42. Tsuji, T., et al., *Epidemiology of low back pain in the elderly: correlation withlumbar lordosis.* Journal of orthopaedic science, 2001. **6**(4): p. 307-311.
43. Hoseinifar, M., F. Ghiasi, and A. Akbari, *The relationship between lumbar and thoracic curves with body mass index and low back pain in students of Zahedan University of Medical Sciences.* J Med Sci, 2007. **7**(6): p. 984-90.
44. Kamali, N., M.H. Ahmadi, and M. Kashami, *The effect of gender and obesity on lumbar lordosis.* J Baboul Univ Med Sci, 2004. **6**: p. 38-39.
45. Tüzün, C., et al., *Low back pain and posture.* Clinical rheumatology, 1999. **18**: p. 308-312.
46. Song, M.-Y., et al., *Correlation between obesity and lumbar lordosis in obese pre-menupausal Korean females.* J Korean Orient Med, 2004. **25**: p. 43-50.
47. Brianezi, L., D. Cajazeiro, and L. Maifrino, *Prevalence of postural deviations in school of education and professional practice of physical education.* Journal of Morphological Sciences, 2017. **28**(1): p. 0-0.
48. Hrysomallis, C. and C. Goodman, *A review of resistance exercise and posture realignment.* The Journal of Strength & Conditioning Research, 2001. **15**(3): p. 385-390.
49. Ashraf, S., et al., *Association between Body Composition, Physical Activity Profile, and Occurrence of Knee and Foot Postural Alterations among Young Healthy Adults.* Future, 2024. **2**(1): p. 16-29.
50. Radaš, J. and T.T. Bobić, *Posture in top-level Croatian rhythmic gymnasts and non-trainees.* Kinesiology, 2011. **43**(1): p. 64-73.
51. Florindo, A.A. and M.d.R.D.d.O. Latorre, *Validation and reliability of the Baecke questionnaire for the evaluation of habitual physical activity in adult men.* Revista Brasileira de Medicina do Esporte, 2003. **9**: p. 129-135.
52. Baecke, J.A., J. Burema, and J.E. Frijters, *A short questionnaire for the measurement of habitual physical activity in epidemiological studies.* The American journal of clinical nutrition, 1982. **36**(5): p. 936-942.
53. Anna, H., et al., *Characteristics of biogeometric profile of posture and quality of life of students during the process of physical education.* 2020.
54. Castro Chacón, L., V.A. Gómez Molina, and R. Landívar Córdova, *Prevalence of postural alterations of the spinal column, associated with the lack of sport habit, in young people from 17 to 22 years old, 2017.* Revista Médica La Paz, 2018. **24**(2): p. 18-23.
55. Malepe, M., et al., *The relationship between postural deviations and body mass index among university students.* Biomedical Research, 2015. **26**(3): p. 437-42.
56. Been, E., et al., *New method for predicting the lumbar lordosis angle in skeletal material.* The Anatomical Record: Advances in Integrative Anatomy and Evolutionary

Biology: Advances in Integrative Anatomy and Evolutionary Biology, 2007. **290**(12): p. 1568-1573.
57. Brech, G.C., et al., *Dynamic postural balance is mediated by anthropometry and body composition in older women.* Acta Ortopédica Brasileira, 2021. **29**: p. 87-91.
58. Misic, M.M., et al., *Muscle quality, aerobic fitness and fat mass predict lower-extremity physical function in community-dwelling older adults.* Gerontology, 2007. **53**(5): p. 260-266.
59. Sharkey, J.R., M.G. Ory, and L.G. Branch, *Severe elder obesity and 1-year diminished lower extremity physical performance in homebound older adults.* Journal of the American Geriatrics Society, 2006. **54**(9): p. 1407-1413.
60. Winters, K.M. and C.M. Snow, *Body composition predicts bone mineral density and balance in premenopausal women.* Journal of Women's Health & Gender-Based Medicine, 2000. **9**(8): p. 865-872.
61. Zhai, M., et al., *Effects of a postural cueing for head and neck posture on lumbar lordosis angles in healthy young and older adults: a preliminary study.* Journal of Orthopaedic Surgery and Research, 2022. **17**(1): p. 199.
62. Delfa-de la Morena, J.M., et al., *Relation of physical activity level to postural balance in obese and overweight Spanish adult males: a cross-sectional study.* International Journal of Environmental Research and Public Health, 2021. **18**(16): p. 8282.
63. Frames, C.W., et al., *Dynamical properties of postural control in obese community-dwelling older adults.* Sensors, 2018. **18**(6): p. 1692.
64. Gonzalez-Galvez, N., G.M. Gea-Garcia, and P.J. Marcos-Pardo, *Effects of exercise programs on kyphosis and lordosis angle: A systematic review and meta-analysis.* PloS one, 2019. **14**(4): p. e0216180.
65. Grabara, M. and A. Hadzik, *Postural variables in girls practicing volleyball.* Biomedical Human Kinetics, 2009. **1**(2009): p. 67-71.
66. Zeyland-Malawka, E., *Effects of prolonged sport training on the sagittal shape of the spine.* Biol Sport, 1989. **6**(3): p. 255-260.
67. Hawrylak, A., et al., *Asymmetry of trunk in athletes of different kind of sport.* Pol. J. Sports Med, 2001. **17**: p. 232-235.
68. Grabara, M., *Comparison of posture among adolescent male volleyball players and non-athletes.* Biology of sport, 2015. **32**(1): p. 79-85.
69. Grabara, M., *A comparison of the posture between young female handball players and non-training peers.* Journal of back and musculoskeletal rehabilitation, 2014. **27**(1): p. 85-92.
70. Muyor, J.M., et al., *Sagittal spinal morphology in highly trained adolescent tennis players.* Journal of sports science & medicine, 2013. **12**(3): p. 588.
71. Wodecki, P., et al., *Sagittal alignment of the spine: comparison between soccer players and subjects without sports activities.* Revue de chirurgie orthopedique et reparatrice de l'appareil moteur, 2002. **88**(4): p. 328-336.
72. Kums, T., et al., *Spinal curvature and trunk muscle tone in rhythmic gymnasts and untrained girls.* Journal of Back and Musculoskeletal Rehabilitation, 2007. **20**(2-3): p. 87-95.
73. Lichota, M., M. Plandowska, and P. Mil, *The shape of anterior-posterior curvatures of the spine in athletes practising selected sports.* Polish Journal of Sport and Tourism, 2011. **18**(2): p. 112-116.
74. Czaprowski, D., et al., *Non-structural misalignments of body posture in the sagittal plane.* Scoliosis and spinal disorders, 2018. **13**(1): p. 1-14.
75. Ferrer López, V., et al., *Repercusiones de la cortedad isquiosural sobre la pelvis y el raquis lumbar.* 1998.

76. Santonja, F. and A. Pastor, *Hamstring shortness syndrome (SHH) and lumbar kiphotic attitud.* Selección, 2003. **12**: p. 150-4.
77. Andreotti, L. and A. Mauric, *Atlas de semiología reumatológica: Generalidades y miembro superior;[2]. Miembro inferior;[3]. Columna vertebral*. 1989: Laboratorios Andreu.
78. Borstad, J.D. and P.M. Ludewig, *The effect of long versus short pectoralis minor resting length on scapular kinematics in healthy individuals.* Journal of orthopaedic & sports physical therapy, 2005. **35**(4): p. 227-238.
79. Vařeková, R., et al., *Evaluation of postural asymmetry and gross joint mobility in elite female volleyball athletes.* Journal of human kinetics, 2011. **29**(2011): p. 5-13.
80. Krzykała, M., *Dual energy X-ray absorptiometry in morphological asymmetry assessment among field hockey players.* Journal of Human Kinetics, 2010. **25**(2010): p. 77-84.

CHAPTER 6 - FINAL CONSIDERATIONS

Chapter 6 – Final Considerations

6.1. Principal Conclusions

As we advance into adulthood, lifestyle changes lead to postural impairments that might impact an individual's quality of life in the present and future. This study aimed to analyze the postural alterations and their association with body composition and Physical Activity levels in the Physical Education and Sports course at the University of Madeira. Some of the most highlighting conclusions of the study included:

Postural alterations concerning the spine, knee, and foot, the most common, were *scoliosis*, *genu recurvatum*, *kyphosis*, *pes planus*, *knee valgus*, *lordosis*, knee varus, and *pes cavus* in two hundred and thirty-one students aged 22.64±4.86 years. A higher proportion of males have spinal, foot, and knee alterations except for *genu recurvatum* due to a higher concentration of males in the sample than females. The occurrence of these postures in university students could be attributed to slouching, poor ergonomic design at universities or homes, and the effects of gravity. Prolonged sitting with the head bent forward on laptops, and improper sitting posture with misalignment of the body are common causes of *kyphosis*, *scoliosis*, and *lordosis*.

The %MG and waist-to-hip ratio are significantly related to knee *genu recurvatum*; however, individuals without *genu recurvatum* have a significant relationship with muscle mass, protein, and minerals. That is attributed to increased fat mass and changes in body fat distribution. *Knee varus*, *knee valgus*, *pes planus*, *pes cavus*, and *lordosis* show no statistically significant relationship with body composition. However, individuals with *scoliosis* showed a statistically significant relationship with *scoliosis*, and height showed a statistically significant relationship with *kyphosis*. In the present study, the mean BMI values (23.38±2.87 and 23.45±3.01) with and without postural changes, respectively, were within the normal range, indicating the absence of obesity in the entire sample, which could be one of the reasons for the lack of a statistically significant relationship between BMI and *knee varus*, *knee valgus*, *pes planus*, *pes cavus*, and *lordosis*.

Formal physical activity shows a statistically significant relationship between *knee valgus* and varus. Moreover, the total (formal and informal) physical activity score illustrates a statistically significant association with *knee varus*. Furthermore, a statistically significant relationship is found between *pes planus* and practical history and frequency of physical

exercise. It could be because of the laxity of soft tissues supporting the arch, including the tibialis posterior muscle, plantar fascia, intrinsic foot muscles, and calcaneonavicular ligaments.

The subjects with postural deformities have higher scores in the physical activity profile; however, *scoliosis* and *kyphosis* do not show a statistically significant relationship. In addition, *lordosis* shows a statistically significant relationship between subjects with and without *lordosis*. Participants with postural deformities have more years of federated exercise, although this is not statistically significant. The higher prevalence of postural changes in subjects with physical activity could be due to systematic and repetitive training, which can influence the alignment of the spinal curves by mechanical loading.

Finally, awareness regarding postural alterations in individuals involved with physical education and special sports could lead to early detection of these alterations and timely management, preventing further deterioration of alignment and other musculoskeletal disorders.

6.2. Practical Implications

This study offers the following practical implications:

Identifying postural abnormalities could help physical education teachers, coaches, and health care professionals design appropriate interventions or corrective exercises to improve body alignment.

Assessment of the students' postural alignment and body composition, potential risk factors can be identified, and preventive measures can be implemented to reduce the risk of injuries during physical activity due to poor posture and imbalance of the body. Flexibility training, or training programs to improve poor posture, could be used to minimize the risk of injury-targeted strength and conditioning exercises. It can also help prevent long-term complications, such as musculoskeletal and neuromuscular disorders, chronic pain, and reduced quality of life.

Understanding the relationship between posture, body composition, and physical activity can help design tailored intervention programs to meet individual needs. Based on the research findings, physical education instructors can develop training programs that address postural issues and promote healthy body composition, optimizing physical activity benefits.

6.3. Limitations of Study

Like other research studies, this study has its limitations. This study has a smaller sample size, and postural assessment was performed through observational analysis of the postures rather than a comprehensive analysis. Another limitation of the study is that we did not provide treatment for postural changes to the students and could not evaluate the changes. Individuals were not categorized according to their specific sports, physical activity, or training quantification.

6.4. Future Recommendations

This study can be improved by using a larger population, analysis of posture through photographs, or measuring angles of the joints (Medial longitudinal arch angles, Cobb's angle, lumbar curve angle, and Q angle, etc.) for better diagnosis. An intervention program includes increasing knowledge of good and bad posture, awareness of postural alterations, common alterations, and symptoms that may trigger further deterioration, exercises to improve postural alterations, normal postural corrections during the daily routine, and workplace postural corrections and activities. Further investigation of the type of physical activity performed and quantification of physical activity can be important to verify postural changes. Research in this area can provide insights into the impact of postural alignment on physical performance and help develop strategies to improve overall athletic ability, agility, and efficiency.

ANNEX – I

POSTURAL ASSESSMENT TABLE

Name _____; No _____.

POSTURAL ASSESSMENT TABLE

LATERAL / SIDE VIEW				
Head	Normal	____	Anteriorization	Posteriorization
		____		
Shoulder	Normal	____	Anteriorization	Poteriorization
		____		
Spine	Normal	Adjustment	Hyperlordosis	Hyperkyphosis
		____		
Pelvis	Normal	____	Retroversion	Anteversion
		____		
Knees	Normal	____	____	Genurecurvatum
		____	____	
Foot	Normal	____	Planus	Cavus
		____		

ANTERIOR/FRONT VIEW				
Head	Normal	____	Inclination	Rotation
		____		
Clavicle	Normal	____	Verticalized	Horizontalized
		____		
Talles Triangle	Normal	____	Increased	Decreased
		____		
ASIS	Normal	____	Symmetric	Asymmetric
		____		
Inferior membranes II	Normal	____	Valgus	Varus
		____		
Knees	Normal	____	Internal Rotation	External Rotation
		____		
Malleolus	Normal	____	Symmetric	Asymmetric
		____		

POSTERIOR/ BACK VIEW				
Shoulders	Normal	____	Elevation	Depression
		____		

Shoulder Blades	Normal	____	Elevation	Depression
		____		
Spine	Normal	____	____	Scoliosis
		____	____	
PSIS	Normal	____	Symmetric	Asymmetric
		____		
Popliteal Lines	Normal	____	Symmetric	Asymmetric
		____	____	
Foot	Normal	____	Valgus	Varus
		____		

ASIS: Anterior Superior Iliac spine; PSIS: Posterior Superior Iliac Spine.

ANNEX – II Baecke Questionnaire

Please, make a circle around the appropriate answer for each question, considering the past 12 months: 1. Do you or did you practice sports or physical exercise within the past 12 months: yes/no Which sport or physical exercise do you or did you practice more often? – how many hours a week? – how many months a year? If you practice or practiced a second modality of sport or physical activity, what is it?: – how many hours a week? – how many months a year?					
2. When compared to others of my age, I think my physical activity during leisure hours is: much more/more/the same/less/much less	5	4	3	2	1
3. During leisure hours, I sweat: very often/often/sometimes/seldom/never	5	4	3	2	1
4. During leisure hours, I practice sports or physical exercises: never/seldom/sometimes/often/very often	1	2	3	4	5
5. During leisure time, I watch TV: never/seldom/sometimes/often/very often	1	2	3	4	5
6. During leisure hours, I walk: never/seldom/sometimes/often/very often	1	2	3	4	5
7. During leisure hours I ride a bike: never/seldom/sometimes/often/very often	1	2	3	4	5
8. For how many minutes a day do you walk or ride a bike going back and forth from work, school or shopping? < 5/5-15/16-30/31-45/> 45	1	2	3	4	5
			Total in minutes		

Formulas for calculating the scores of the Baecke questionnaire of AFH
Physical exercise at leisure (LE)

Calculation of the first question regarding the practice of sports/physical exercises:
• Intensity (type of modality) = 0.76 for modalities with light energy expenditure or 1.26 for modalities with moderate energy expenditure, or 1.76 for modalities with vigorous energy expenditure (determined by the modality type response: energy expenditure of the modality should be checked in Ainsworth's compendium of physical activities13) • Time (hours per week) = 0.5 for less than one hour per week or 1.5 for more than one hour and less than two hours per week or 2.5 for more than two hours and less than three hours per week or 3.5 for more than three and up to four hours per week or 4.5 for more than four hours per week (determined by the response of hours per week of practice) • Proportion (months per year) = 0.04 for less than one month or 0.17 between one and three months or 0.42 between four and six months or 0.67 between seven and nine months or 0.92 for greater than nine months (determined by the response of months per year of practice)
To calculate the score for this question, the values must be multiplied and added: Mode 1 = (Intensity*Time*Ratio) + Mode 2 = (Intensity*Time*Ratio) **For the final value, a score will be stipulated according to the values obtained in the formula:** 0 (no physical exercise) = 1/between 0.01 to < 4 = 2/between 4 to < 8 = 3/between 8 to < 12 = 4/ÿ 12.00 = 5
The scores of questions two to four will be obtained according to the answers of the Likert scales Formulas for calculating the scores of the Baecke questionnaire of AFH. **The final EFL score must be obtained according to the formula specified below:**
EFL score equals question 1 + question 2 + question 3 + question 4 divided by 4.
Physical leisure activities and locomotion (ALL)
The scores of questions five to eight will be obtained according to the answers of the Likert scale. **The final ALL score must be obtained according to the formula specified below:**
All Score equals (6 - question 5) + question 6 + question 7 + question 8 divided by 4.
Total score (ET) = EFL + ALL

ANNEX - III

INFORMED CONSENT

Departamento de Educação Física e Desporto
Caro aluno,

No âmbito de uma dissertação de Mestrado em Atividade Física e Desporto na Universidade da Madeira, pretendemos desenvolver o projeto de investigação intitulado "Alterações posturais em alunos da Licenciatura em Educação Física e Desporto da Universidade da Madeira --- Relação com a Composição Corporal e Perfis de Atividade Física".

Da caracterização à conceção de um programa de intervenção: um estudo com alunos da Licenciatura em Educação Física e Desporto da Universidade da Madeira".

Esta investigação tem como objetivo (i). Avaliar as alterações posturais; (ii). Com base na atividade física, avaliar as alterações posturais; (iii). Com base na composição corporal, avaliar as alterações posturais; (iv). Com base no histórico esportivo, avalie as alterações posturais.

Procedimentos

Os alunos que gentilmente aceitaram participar neste projeto serão avaliados em dois momentos (avaliações em contexto laboratorial, com uma duração nunca superior a 5 minutos) e preencherão um pequeno questionário online. A participação numa ação de formação será solicitada entre os dois momentos de avaliação.

Risco

Durante as avaliações físicas, não são previstos riscos ou desconforto para os participantes. Terapeutas qualificados realizarão todas as avaliações e coletas.

Mais se informa que todos os participantes terão acesso ao tratamento de dados, avaliações, diagnósticos e conclusões que lhes digam respeito.

Embora seja solicitado a cada participante que se identifique nos questionários/avaliações a realizar, toda a informação recolhida será confidencial. Os resultados do estudo serão publicados, mas em nenhum momento será revelado o nome ou identidade de qualquer participante.

Se você deseja fazer parte deste desafio, preencha as seguintes informações:

Nome: _____ N.º de Estudante: _____Year: _____ Data de nascimento: / / ;

E-mail: @ _____ ; Número de telemóvel: _____ ;

Muito obrigado pela sua colaboração!