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Impact of Custom Foot Orthosis on Dynamic Balance in Sports Enthusiasts with Flat Feet

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Abstract

Background: Custom foot orthoses (CFOs) have been extensively studied for their effectiveness in redistributing plantar pressure, aligning foot structure, and enhancing stability in individuals with flatfoot (Desmyttere et al., 2019; Xu et al., 2020). Flatfoot, characterized by reduced or absent arches, often leads to overpronation and compromised musculoskeletal alignment, impacting dynamic balance and elevating injury risk during physical activity (Hawke et al., 2015). This study examines the impact of CFOs on dynamic balance specifically in sports-active individuals with flatfoot, where optimal balance is critical due to rapid directional changes and stability demands. By providing customized support, CFOs may serve as a practical intervention to improve stability and support safe sports participation.
Methods: This quantitative, experimental study used a one-group pre-test and post-test design with purposive sampling. Twelve subjects participated, and dynamic balance was measured using the Modified Bass Dynamic Balance Test.
Results: Statistical analysis with a paired-sample t-test yielded a p-value of 0.002, indicating a significant positive effect of CFOs on dynamic balance ($p < 0.005$).
Conclusion: The findings indicate a positive effect of CFOs on dynamic balance in flatfoot individuals engaged in sports. It is recommended that individuals with flatfoot, particularly those involved in sports, consider CFOs to improve balance and reduce injury risk. Regular assessments by healthcare professionals may further optimize orthotic benefits for enhanced performance and stability.

Keywords: Dynamic Balance, Custom Foot Orthosis, Flat Foot

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Introduction

Proper exercise or physical training is essential for achieving a good level of physical fitness, which plays a significant role in enhancing human resource quality (Kukut, 2015). Physical activities like sports are particularly popular among adolescents (Damayanti, 2016), involving key motor components such as speed, agility, balance, coordination, and accuracy (Santika, 2015). Balance is crucial for reducing injury risks, improving muscle function, and performing quick movements, which are especially important for those with flatfoot, a condition linked to musculoskeletal issues in the feet that can impair balance and coordination (Susi, 2019). Balance is defined as the body's ability to control its center of mass over its base of support, which can be static (at rest) or dynamic (in motion) (Trindade, M. A., et al., 2017). Static balance measurements in stable and unstable conditions do not discriminate groups of young adults assessed by the Functional Movement Screen™(FMS™). *International Journal of Sports Physical Therapy*, *12*(6), 858.

Flatfoot occurs when the medial longitudinal arch of the foot does not develop fully, causing the entire sole to make contact with the ground, which may lead to balance disorders and increased injury risk (Houglum & Bertoti, 2012). Custom foot orthoses (CFOs) have shown promise in redistributing plantar pressure, enhancing stability, and alleviating pain caused by improper foot function (Wrobel et al., 2015). Custom orthoses are especially beneficial for flatfoot, as they provide tailored support to improve biomechanics and restore functional balance. In studies on medial arch support, CFOs were shown to improve dynamic balance, especially in physical activities that demand constant body movement and stability.

Prosthetic orthotic services can address these needs by offering CFOs to help individuals with flatfoot conditions, enhancing their stability during activities and potentially reducing fatigue and injury. Based on a preliminary study, 29 out of 125 students in the Orthotic Prosthetic major with flatfoot conditions reported challenges with balance during practical tasks. Given these issues, this study aims to assess the effect of CFOs on dynamic balance in flatfoot students who are actively engaged in sports, examining how CFOs may help alleviate balance issues, prevent fatigue, and reduce the likelihood of falls during physical activities.

Methods

The research method used in this research is quantitative method. The type of research used is an experiment, namely *one group pre test and post test design*. With the aim of knowing the effect of using *custom foot orthosis* on dynamic balance in *flat foot* conditions before and after using the tool. Research designs such as

O_1 - X - O_2

Figure 1: Research design

Image caption:

O_1 : The state of the subject has not been treated. In this case a *pre-test* was conducted

x : Treatment, namely the provision of intervention using *custom foot orthosis* for 2 weeks

O_2 : The state of the subject after being treated. In this case a *post-test* was conducted

The research will be conducted in August-December 2023. The research will be conducted at Campus 2 of the Health Polytechnic of the Ministry of Health Surakarta. The population in this study were undergraduate students of the Applied Orthotic Prosthetics Polytechnic of the Ministry of Health Surakarta totaling 235 people. In this study, the authors used a sampling technique in the form of non-probability sampling with purposive sampling. Purposive sampling is a method of determining respondents to be sampled based on certain criteria.

In this study, to measure the value of dynamic balance using the *modified bass test* instrument. This test is a jumping movement with a point area made zigzag using one foot as a pedestal and stopping for a moment after landing (Johnson *et al.*, 2010).

The variables of this study are divided into 2, namely the independent variable (independent) is the use of *custom foot orthosis* and the dependent variable (dependent) is dynamic balance.

The data collection method consists of the research preparation stage, the implementation stage. Data analysis using SPSS 16 for windows with normality test, hypothesis testing.

Results

Research on the effect of using *custom foot orthosis on* dynamic balance in *flat foot* conditions with sports hobbies was conducted on undergraduate students of the Applied Orthotic Prosthetics Polytechnic of the Ministry of Health Surakarta with a total population of 235 students. From this population, a representative sample of 12 students with *flat foot* conditions who like to exercise was determined. The research was conducted in August-November 2023 at the Department of Orthotic Prosthetics Campus 2 of the Health Polytechnic of the Ministry of Health Surakarta.

Data collection was carried out by examining *flat feet* with a *wet footprint test* on all samples. The intervention that can be given by researchers to respondents is *custom foot orthosis* by molding the respondent's *foot* using a *plaster roll*. In this study, the research subject group was given an intervention using *custom foot orthosis* with control use for 2 weeks. The research instrument used was the *modified bass test*.

Respondent Characteristics

a. Gender

Table 1. Description of Gender of Research Respondents

Gender	Number of Subjects	Percentage (%)
Female	9	75%
Male	3	*25%*
Total	**12**	**100**

Source: Primary Data (2023)

Based on data from undergraduate students of the Applied Orthotics Prosthetics Polytechnic of the Ministry of Health Surakarta, there are 235 student populations. The incidence of *flat feet is* more common in women than men.

b. Age

Table 2. Age Description of Research Respondents

Age	Number of Subjects	Percentage (%)
18	4	33.3%
19	4	33.3%
20	4	33.3%
Total	**12**	**100**

Source: Primary Data (2023)

Data from the undergraduate applied orthotic prosthetics polytechnic health ministry of health surakarta a total of 235 student population, shows that the majority of students are teenagers. Namely between the ages of 12 years to 24 years. This age is an adolescent age group based on WHO.

c. Height, Weight and BMI

Table 3. Description of Height, Weight and BMI of Research Respondents

	Number of Subjects	Min.	Max.	Average
Body Weight	12	47.0	67.0	55.733
Height	12	150	171	159.58
IMT	12	18.83	22.94	21.6975

Source: Primary Data (2023)

In this study, there were 12 respondents with BMI conditions that fell into the normal category. Based on WHO classification, BMI can be said to be normal if the results are obtained in the range of 18.5 to 22.9.

d. Dynamic Balance

Dynamic balance in this study using the *modified bass test* instrument.

Table 4. *Modified Bass of Dynamic Balance Test* Criteria

No.	Dynamic Balance	Criteria
1.	14-31	Less
2.	32-49	Medium
3.	50-68	Good

Dynamic balance criteria are said to be lacking if the balance value is 14-31, said to be moderate if the value is 32-49 and good balance if the value is 50-68.

Table 5. Description of the study's dynamic balance criteria

	Pre test	Post test	Min.	Max.
Less	0	0	0	0
Medium	0	0	0	0
Good	12	12	59	92

Table 5 shows the distribution of dynamic balance scores among participants based on set criteria before and after the intervention (pre-test and post-test). All participants (12 out of 12) achieved a "Good" rating in both the pre-test and post-test, meaning there was no change in their dynamic balance classification from before to after the intervention.

The scores for participants in the "Good" category ranged from a minimum of 59 to a maximum of 92, indicating varying degrees of dynamic balance within the "Good" range but no participants falling into the "Less" or "Medium" categories.

This suggests that all participants maintained a high level of dynamic balance throughout the study, as no one scored in the lower categories at any point.

Table 6. Description of Dynamic Balance of Research Respondents

Number of Subjects		Min.	Max.	Average
Pretest	12	59	87	71.08
Posttest	12	66	92	79.83

Source: Primary Data (2023)

There were 12 participants in both the pretest and posttest phases. In the pretest, the lowest dynamic balance score was 59, which improved to 66 in the posttest. The highest score recorded was 87 in the pretest, which increased to 92 in the posttest.

The mean dynamic balance score for respondents was 71.08 before the intervention (pretest) and improved to 79.83 after the intervention (posttest).

Data Analysis

Data analysis used to determine the effect of using *custom foot orthosis* on dynamic balance in *flat foot* conditions with sports hobbies is using a 2-group paired comparative test. To test this hypothesis, the IBM SPSS (*Statistical Product and Service Solution*) calculation program version 25 can be used.

a. Normality Test

Table 7. Dynamic Balance Normality Test

Normality Test				
	Shapiro-Wilk			
	Statistics	Number of subjects	Significant	Description
PRE	0.878	12	0.083	Normal
POST	0.935	12	0.436	Normal

Source: Primary Data (2023)

For the **PRE**test, the Shapiro-Wilk statistic is 0.878, with a significance level (p-value) of 0.083 for 12 subjects, indicating the data distribution is normal since $p > 0.05$.

For the **POST** test, the Shapiro-Wilk statistic is 0.935, with a significance level of 0.436 for the same 12 subjects, also indicating a normal distribution ($p > 0.05$).

The results suggest that both the pre- and post-intervention dynamic balance data conform to a normal distribution.

b. Hypothesis Test

Table 8. Paired T Test

Paired T Test	
	significant
PRE - POST	0.002

Source: Primary Data, 2023

Based on the Paired T Test table shows a significant value of ($p < 0.05$), it can be concluded that there is an effect of using *custom foot orthosis* on dynamic balance in *flat foot* conditions with sports hobbies before and after using *custom foot orthosis*.

Discussion

The characteristics of the subjects in this study have mostly consisted of women with a percentage of 75% with a total of 9, while male subjects amounted to 3 with a percentage of 25%. This happened because the subjects who met the inclusion and exclusion criteria were women. With Body Mass Index (BMI) the subjects of this study were all normal with a BMI range of 18.5-22.9 because subjects who had normal BMI were one of the inclusion criteria.

The subjects of this study had an age range of 18 to 20 years because at that time the medial arch should have begun to form. At this age, *flat foot* detection can be done using the *wet footprint test*. This shows that the arch will continue to develop and increase with age (Tong, J.W *et al.*, 2016.

Balance can be defined as the body's ability to control body mass (*center of mass*) against the fulcrum (*base of support) to* fight gravity (*center of gravity)* (Risangdiptya *et al.*, 2016). A person with a *flat foot* condition tends to be lacking in body balance, because the fulcrum on the foot has little contact with the ground surface. People who have a normal arc are better balanced than people whose arc grows abnormally, which will have an impact on balance disorders (Rosdiana, 2022).

The mechanism of action of *custom foot orthosis* is to correct foot pronation and to maintain balance. The insole is made in expanding the contact surface of the foot to increase stability during weight bearing (Eun-Kyung, *et al.*, 2016). *Custom foot orthosis* is a type of orthosis that is attached to the *medial* part of the *longitudinal archus* which is custom made to adjust the shape of the human foot.

Based on the *posttest* results, there is an increase in dynamic balance after the intervention, thus showing that *custom foot orthosis is* effective in improving dynamic balance in students who like to exercise. The average value of dynamic balance results before the intervention was 71.08 while after the intervention was 79.83. from the results of this study, the average value of dynamic balance in students with sports hobbies has increased by 8.75 (12.31%) with a significant value of 0.002 ($p < 0.05$). So, it can be concluded that there is a statistically significant effect of using *custom foot orthosis* on dynamic balance in *flat foot* conditions with sports hobbies.

This statement is in accordance with the research of Ali Yalfani, *et.al* year (2023) which states that *foot orthosis* with *medial longitudinal arch support* can cause flexible *flatfoot* correction and provide mechanical stability to the foot and ankle complex. Research by Sue Min Lee, *et.al in* (2022) also states that insole intended for *flat foot* conditions can maintain the *medial arch* of the foot and can help improve foot function and dynamic balance mechanics in *flat foot* conditions.

The use of *insole* with arches on the medial part of the foot for 2 weeks can help improve the alignment of the respondent's body according to the body's line of gravity so that the body's balance will be more stable. As a person who likes to exercise body balance is a major thing that is needed to maintain the body while exercising, the arch on the medial foot will maintain the position of the body balance in accordance with the line of gravity when used to jump, walk and run.

This statement is in accordance with Malia's research (2019) which states that there is little difference in vertical and horizontal jumps observed in flat-footed and normal basketball players, regardless of the use of *foot orthosis*. The use of *foot orthosis* reduces ankle eversion during jumping and reduces horizontal *ground reaction force* and ankle movement in the *standing broad jump during the* take-off phase. During walking and running, the use of the *foot orthosis* resulted in a reduction in ankle eversion of between 1 and 3° for all participants during *countermovement jump* and *standing broad jump*. One possible explanation is that when jumping from a stationary position, the foot propels primarily using the forefoot. This is unlike other forms of locomotion such as walking and running where there is a lot of hindfoot and midfoot engagement during ground contact. The *foot orthosis* used in our study provides support primarily to the hindfoot and midfoot areas.

Conclusion

Research on the effect of using *custom foot orthosis* on dynamic balance in *flat foot* conditions with sports hobbies conducted in August - December 2023 at Campus 2 of the Health Polytechnic of the Ministry of Health Surakarta with a population of 235 people and sampling techniques using purposive sampling resulted in a sample of 12 people. The dynamic balance instrument in this study was measured using the *modified bass* test and then tested using the paired T test. The test results showed a significant value of 0.002 ($p < 0.05$) so that it can be said that there is an influence. The average value of dynamic balance in *flat foot* conditions after giving *custom foot orthosis* for 2 weeks there is an increase in balance of 8.75 (12.31%).

It can be concluded that giving *custom foot orthosis* for 2 weeks has an effect on the dynamic balance of a person with a *flat foot* condition with a sports hobby.

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