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Original Article

Physiotherapy Section

Body Mass Index and its Association with Active Ankle Proprioception in Healthy Young Individuals: A Cross-sectional Study

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ABSTRACT

Introduction: Proprioception plays an important role in generating movements that are free and coordinated, aiding in the maintenance of normal body posture, regulating balance and postural control, and facilitating motor learning. Body Mass Index (BMI), a measure of weight adjusted for height, is commonly used to assess obesity in adults.

Aim: To explore the association of ankle proprioception with BMI in healthy young individuals.

Materials and Methods: This cross-sectional study was conducted on students of Sumandeep Vidyapeeth University between May 2023 and December 2023. Students aged between 18 and 40 years, without any known pathology, were approached, and a total of 112 individuals were screened. Out of these, 108 subjects were included in the study, consisting of 96 females and 12 males. The outcome measures used were Joint Position Sense (JPS) and BMI. JPS was assessed at three different angles: 30%, 60%, and 90% of the total range of active ankle inversion and eversion, specifically at 42° of plantar flexion, as measured by a pedal goniometer. The Chi-square test was used to establish the association between categorical variables. BMI was calculated by measuring the weight and height of the subjects, using the formula BMI=kg/m². Data were analysed at a 5% level of significance, with a Confidence Interval (CI) of 95%.

Results: No significant association was found between BMI and active ankle proprioception at 30%, 60%, and 90% angles (p-value >0.05).

Conclusion: According to this study, BMI was not found to be associated with ankle proprioception in healthy individuals, particularly regarding the active range of motion in a non weight-bearing position. The study also suggests that the pedal goniometer is a cost-effective tool that can be used to measure the proprioception of the ankle joint effectively.

Keywords: Ankle joint, Goniometer, Healthy individual

INTRODUCTION

Proprioception, initially defined by Sherrington in 1906 as "the perception of joint and body movement, as well as the position of the body or body segments in space," is currently understood as the cumulative neural input to the central nervous system from specialised nerve endings called mechanoreceptors. These mechanoreceptors are situated in the joint capsules, ligaments, muscles, tendons and skin [1].

The assessment of proprioception typically involves measuring JPS and the sense of limb movement. JPS helps in assessing a subject's ability to identify a proposed joint angle and reproduce it both actively and passively after the position has been removed. Colledge NR et al., observed that individuals of all age groups rely more on proprioception than vision for maintaining balance [1]. Both components of proprioception play an important role in generating movements that are free of hassle and in co-ordination, which is essential for the maintenance of normal body posture, regulating balance and postural control and facilitating motor learning [1]. However, to use a body part, Active Range of Motion (AROM) plays a major role, utilising muscles, tendons and all the surrounding structures. Hence, assessing proprioception actively should be considered more useful [2].

BMI, a measure of weight adjusted for height, is commonly used to assess obesity in adults [3]. Overweight or obesity, especially in childhood, can lead to various functional problems such as joint stiffness, pain (particularly in the lower limb), muscle weakness, and postural deformities. Over the past decade, there has been an increased emphasis on research into proprioception, particularly focusing on anatomical areas such as the knee and ankle joints, which play a significant role in maintaining the integrity of the lower extremities in the kinematic chain [4].

The ankle joint, being the most proximal joint to the body's base of support, plays an important role in maintaining balance. There are different methods available for assessing ankle joint proprioception, including JPS, sense of limb movement, active-to-active reproduction tests, pedal goniometer assessments, Active Movement Extent Discrimination Assessment (AMEDA), Threshold to Detection of Passive Motion (TTDPM) and Ankle Inversion Discrimination Apparatus for Landing (AIDAL) [1,5-9].

Studying the relationship between BMI and ankle proprioception in healthy young individuals is essential for gaining insights into how body weight influences sensory perception and joint stability. Understanding this connection could have implications for injury prevention, rehabilitation and overall musculoskeletal health [10].

In the present study, an attempt was made to assess active ankle joint proprioception using a pedal goniometer, a highly reliable and clinically feasible method.

Null hypothesis: There is no statistically significant association between BMI and active ankle proprioception in healthy young individuals.

Alternate hypothesis: There is a statistically significant association between BMI and active ankle proprioception in healthy young individuals.

MATERIALS AND METHODS

This cross-sectional study was conducted on students at Sumandeep Vidyapeeth University between May 2023 and December 2023. Approval was obtained from the Sumandeep Vidyapeeth Institutional Ethics Committee (SVIEC No: SVIEC/ON/PHYS/BNOPS22/APRIL/23/5) and registered with the Clinical Trial Registry India (CTRINO: CTRI/2023/05/067116). After securing approval for the study, data were collected from students at the College of Physiotherapy, Sumandeep Vidyapeeth. Students were screened based on the following inclusion and exclusion criteria.

Inclusion criteria: Students aged between 18 and 40 years of both genders and giving consent were included in the study.

Exclusion criteria: Any history of musculoskeletal injuries, any surgical history involving the lower limb, any congenital deformities of the lower limb, a history of known disorders such as diabetes mellitus or hypertension, and any neurological problems were excluded from the study.

Sample size calculation: Sample size formula $Z'=0.5*\ln((1+r)/(1-r))$ where r=correlation coefficient=0.8 so, Z'=1.10.

Sample size $n=((z1\text{-}alpha/2\text{-}z1\text{-}beta)/(Z'*ro\text{-}Z'*r1))^{+3}$ Where z1-alpha/2=1.96 Z1-beta=0.84 ro=0.80, r1=0.70 So, n=108 [11].

Convenient sampling was used to collect the data. A total of 112 subjects were screened for the study, of which four were excluded due to being underage and having a lower limb fracture, resulting in 108 subjects being included in the study. A participant information sheet was provided to all participants, and all subjects were assessed in detail.

Study Procedure

After screening for inclusion and exclusion criteria, the selected participants were informed about the study, and informed consent forms were obtained from all participants. Demographic data were collected from all participants.

To measure BMI [3]: The calculation of BMI involves a person's height and weight. The formula for BMI is expressed as BMI=kg/m^2, where "kg" represents a person's weight in kilograms, and "m^2" signifies their height in meters squared. The BMI is further divided into categories according to the Asian population.

- Underweight <18.5
- Normal 18.5-24.9
- Overweight 25-29.9
- Obese ≥30

To measure active ankle proprioception [6]: JPS testing was conducted using a pedal goniometer. This instrument was first introduced by Chan M et al., in 1990, and a similar concept was developed by Boyle J in 1998 in their study. As no brand or manufacturer currently provides a pedal goniometer, the original concept was utilised, and the device was designed and prepared by the authors, as shown in [Table/Fig-1]. The subject's foot was placed on the pedal at 42° of plantar flexion, allowing for ankle inversion and eversion along a horizontal axis within the frontal plane. An Orthoplast cuff was used to stabilise the subject's calcaneus, securing the subject's leg and foot to the pedal.

[Table/Fig-1]: Pedal goniometer used in the study.

The evaluation of each subject's ability to replicate predetermined joint positions followed a standardised procedure with verbal instructions. To eliminate visual cues, subjects were blindfolded during the testing sessions. Active JPS was assessed by positioning the subject's ankle at three different inversion and eversion angles: 30%, 60% and 90% of their total range of active ankle inversion and eversion, specifically at 42° of plantar flexion, as measured by the pedal goniometer. Using percentage increments ensures that the ankle positioning is relative to each individual's range of motion.

To assess JPS, the subject's ankle was manually moved at a rate of approximately five degrees per second from the starting position (neutral inversion/eversion) to the first testing position. Subjects were given three seconds to register the position before returning to the starting position. In the active test, the subject was instructed to perform an AROM inversion and eversion movement, aiming to stop at the test position. The testing order (three different positions and two methods) was randomised. The absolute error, defined as the difference between the actual and perceived position, was recorded to the nearest 0.5°. Each position underwent three trials.

STATISTICAL ANALYSIS

Data were analysed using the Statistical Package for the Social Sciences (SPSS) version 28.0. All categorical variables, such as age, gender, and BMI, were summarised. The Chi-square test was used to establish associations between categorical variables. Data were analysed at a 5% level of significance with a Confidence Interval (CI) of 95%.

RESULTS

A total of 108 subjects were included in the study, of which 96 were females and 12 were males. All categorical variables, such as age, gender, and BMI, is shown in [Table/Fig-2]. Ankle proprioception in active motion was also presented as a percentage or the number of subjects [Table/Fig-3,4]. The Chi-square test was used to establish associations between categorical variables. The results indicate that BMI and ankle proprioception—specifically at 30%, 60%, and 90% AROM for both inversion and eversion—do not have a statistically significant association (p-value >0.05).

Demographic	M±SD
Age (years)	22.25±1.64
Height (cm)	159.80±7.2
Weight (kg)	57.1±10.48
BMI (kg/m^2)	22.28±3.3

[Table/Fig-2]: Demographic details of subjects.

	BMI	Normal	Affected	Chi-square	p-value
Ankle proprioception 30% AROM inversion (right)	<18.5	2 (1.85%)	8 (7.40%)	2.984	0.394
	18.5-24.9	17 (15.74%)	58 (53.70%)		
	25-29.9	7 (6.48%)	12 (11.11%)		
	≥30	2 (1.85%)	2 (1.85%)		
Ankle proprioception 60% AROM inversion (right)	<18.5	2 (1.85%)	8 (7.40%)	2.136	0.545
	18.5-24.9	32 (29.63%)	43 (39.81%)		
	25-29.9	7 (6.48%)	12 (11.11%)		
	≥30	2 (1.85%)	2 (1.85%)		
Ankle proprioception 90% AROM inversion (right)	<18.5	6 (5.56%)	4 (3.70%)	2.749	0.432
	18.5-24.9	42 (38.89%)	33 (30.56%)		
	25-29.9	13 (12.03%)	6 (5.56%)		
	≥30	1 (0.93%)	3 (2.78%)		
Ankle proprioception 30% AROM inversion (left)	<18.5	2 (1.85%)	8 (7.40%)	4.214	0.239
	18.5-24.9	31 (28.70%)	44 (40.74%)		
	25-29.9	4 (3.70%)	15 (13.89%)		
	≥30	2 (1.85%)	2 (1.85%)		

Ankle proprioception 60% AROM inversion (left)	<18.5	4 (3.70%)	6 (5.56%)	0.828	0.843
	18.5-24.9	22 (20.37%)	53 (49.07%)		
	25-29.9	7 (6.48%)	12 (11.11%)		
	≥30	1 (0.93%)	3 (2.78%)		
Ankle proprioception 90% AROM inversion (left)	<18.5	2 (1.85%)	8 (7.40%)	1.378	0.706
	18.5-24.9	18 (16.67%)	57 (52.78%)		
	25-29.9	5 (4.63%)	14 (12.96%)		
	≥30	0	4 (3.70%)		

[Table/Fig-3]: Association between BMI and active ankle inversion at different angles.
p<0.05 suggests statistical significance

	BMI	Normal	Affected	Chi-square	p-value
Ankle proprioception 30% AROM eversion (right)	<18.5	1 (0.93%)	9 (8.33%)	4.027	0.259
	18.5-24.9	8 (7.40%)	67 (62.03%)		
	25-29.9	5 (4.63%)	14 (12.96%)		
	≥30	0	4 (3.70%)		
Ankle proprioception 60% AROM eversion (right)	<18.5	3 (2.78%)	7 (6.48%)	6.790	0.079
	18.5-24.9	38 (35.19%)	37 (34.26%)		
	25-29.9	7 (6.48%)	12 (11.11%)		
	≥30	4 (3.70%)	0		
Ankle proprioception 90% AROM eversion (right)	<18.5	5 (4.63%)	5 (4.63%)	0.543	0.909
	18.5-24.9	33 (30.56%)	42 (38.89%)		
	25-29.9	10 (9.26%)	9 (8.33%)		
	≥ 30	2 (1.85%)	2 (1.85%)		
Ankle proprioception 30% AROM eversion (left)	<18.5	1 (0.93%)	9 (8.33%)	1.533	0.675
	18.5-24.9	13 (12.03%)	62 (57.40%)		
	25-29.9	2 (1.85%)	17 (15.74%)		
	≥30	0	4 (3.70%)		
Ankle proprioception 60% AROM eversion (left)	<18.5	2 (1.85%)	8 (7.40%)	3.851	0.278
	18.5-24.9	28 (25.93%)	47 (43.52%)		
	25-29.9	8 (7.40%)	11 (10.19%)		
	≥30	3 (2.78%)	1 (0.93%)		
Ankle proprioception 90% AROM eversion (left)	<18.5	4 (3.70%)	6 (5.56%)	4.318	0.229
	18.5-24.9	40 (37.04%)	35 (32.41%)		
	25-29.9	11 (10.19%)	8 (7.40%)		
	≥30	4 (3.70%)	0		

[Table/Fig-4]: Association between BMI and active ankle eversion at different angles.
p<0.05 suggests statistical significance

DISCUSSION

The ankle is a type of hinge joint responsible for the movement and stability of the lower limb during activities such as sitting, standing, walking and running. JPS is essential for completing these activities and is provided by mechanoreceptors located in and around the ankle joint [4,12].

In this study, a pedal goniometer was used to assess ankle proprioception. This instrument is commonly employed for reproducing joint positions both actively and passively, as well as for detecting deviations in joint position [6]. Therefore, this method is utilised to assess JPS objectively, especially in a non weight-bearing position [13]. Different percentages or increments of ankle range of motion were used in the study to allow for individual assessment of proprioception, thus avoiding the need to follow a generalised protocol. According to a study conducted by Chan M et al., the reliability of the pedal goniometer for assessing inversion at the ankle joint in the plantar flexed position was found to be high [14].

In the present study, no statistically significant association was found between BMI and AROM of inversion and eversion at 30%, 60%, and 90% for both the right and left sides [Table/Fig-3,4]. A similar study conducted by Lazarou L et al., on the ankle and knee joints found no statistically significant association between BMI and active proprioception for both joint types [15]. They observed that obesity affects knee joint proprioception but does not have any association with BMI and ankle joint proprioception. They suggested that active exercise can induce fatigue, which may disturb joint position, potentially explaining the lack of association. According to their findings, weight does not play a role in disrupting joint sense. They also indicated that proprioception plays a crucial role in detecting small changes in joint position through sensory receptors in the muscle spindles of the joints and muscles, underscoring the importance of actively engaging proprioception [16].

There is limited literature on how BMI influences ankle position; however, various studies have examined the effect of obesity on knee proprioception at three different knee flexion target angles. Findings indicated that overweight participants exhibited significantly worse joint position awareness abilities. This could be attributed to muscular atrophy in overweight individuals, a reduced number of active muscle spindles and consequently poorer proprioceptive ability [15-17]. Furthermore, overweight or obesity, particularly in childhood, can lead to a range of functional problems, including joint stiffness and pain (especially in the lower limbs), muscle weakness, and postural deformities, which can adversely affect postural control and movement ability [18].

In light of the present study, BMI is not associated with active ROM of the ankle; hence, the alternative hypothesis is rejected, and we accept the null hypothesis. Weight does not pose a barrier to treating ankle JPS. Future studies could investigate other factors for a better understanding of ankle proprioception. While this study does not demonstrate any influence of BMI on active ankle proprioception, further research could be conducted to ascertain whether passive proprioception is impacted.

Limitation(s)

The study does not include the active ROM of the ankle joint to assess any associations. Other factors, such as mobility and muscle strength, could be considered to explore potential associations. Furthermore, the study targeted only physiotherapy students, which may be a significant confounding factor, as physiotherapists are more engaged in standing work, potentially leading to improved stability and proprioception, regardless of BMI. It would be beneficial to examine different populations with varying types of work. Conducting the study on diverse populations could help to generalise the results and evaluate the effects of other variables on proprioception.

CONCLUSION(S)

According to this study, BMI was not found to be associated with ankle proprioception in healthy individuals, particularly the active range of motion in a non weight-bearing position. Hence, it suggests that weight is not a barrier when treating ankle proprioception. The study also indicates that a pedal goniometer is a cost-effective tool that can be used to measure ankle joint proprioception effectively.

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