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Influence of Body Mass Index on Ankle Proprioception in Adult Females

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Abstract: This study was conducted to investigate the effect of body mass index on ankle proprioception in adult females.eighty- seven adult females participated in the study, their age ranged between(18-35) years old. Subjects were divided into three groups, each group consists of 29 female subjects. Group A(control group): Females with BMI (18-24.9)Kg/m^2. Group B: Females with BMI (25-29.9)Kg/m^2, Group C: Females with BMI (30-34.9) Kg/m^2. The isokinetic dynamometer was used to measure ankle joint proprioception. The results showed that there was a significant difference in ankle active repositioning error between normal subjects and obese subjects (p value<0.05). However there was no significant difference in ankle active repositioning error between normal and overweight subjects and between overweight and obese persons (p value < 0.05). Obese adult females have deficit on their ankle proprioception.

Key words: Ankle · BMI · Obesity · Proprioception

INTRODUCTION

Obesity is considered a huge problem in the world, obesity is the cause of many medical conditions, including hypertension, stroke, type I diabetes, gout, osteoarthritis, certain cancer and various musculoskeletal disorders, particularly of the lower limbs and feet [1, 2].

Proprioception is a complex sense that relies on information from sensory (somatosensory) vision and vestibular inputs based on the sum of afferent information. Efferent stimuli are generated in the central nervous system, these stimuli activate appropriate agonistic and opposite muscle groups which reposition joints and extremity segments, This process of repositioning generates further sensory stimuli and thus maintaining a feedback system which continuously monitors the motor functions of body and extremities and result in co-ordinated movements [3].

The proprioception is important for balance control. The Three balance sense work together and aid in the regulation of balance, which the most important is somatosensory when disrupted affect balance and increase postural sway (Bernier and Perrin, 1998 The ability to maintain balance during standing on a single leg or both legs require the integrity of the visual, vestibular and nervous systems. In the presence of an intact vestibular system, standing with the eye closed depends mostly on the normal function of the various proprioceptors [4].

Proprioceptive acuity in the ankle becomes the focus of a number of investigations. Since the proper functioning of this joint is critical to the integrity of the lower kinematics' chain, alternation in proprioceptive awareness may have profound effects on performance [5].

Ankle Joint has an important role in controlling balance. The main considering point in balance regulation is the stability of the ankle joint [6].

The major joints of the lower extremity of an individual with normal weight are exposed to reaction forces of approximately three to six-time body weight during locomotion (single leg stance). An increase in BMI is associated with a decrease in muscular strength per mass ratio [7]. Consequently, relative to body weight, obese individuals tend to be weaker than normal weight individuals.

Therefore the purpose of this study was to study the effect of increased body mass index on ankle proprioception in adult females.

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MATERIALS AND METHODS

This study was conducted in the isokinetic lab of the faculty of physical therapy, Cairo University to investigate the effect of body mass index on ankle proprioception in adult females.

Design: Cross-sectional study.

Ethical Approval: All relevant national laws and institutional policies have been followed up in human use research, followed the principles of the Helsinki Declaration and approved by the Research Ethics Committee of the Faculty of Physical Therapy, Cairo University(REC/012/001340).

Participants: Subjects were recruited from the students and employees of the faculty of physical therapy, Cairo University. All subjects read and signed the informed consent form, Subjects enrolled in the study have the following inclusion criteria: adult female subjects, Age ranging between (18-35) years old and body mass indexes between (18-34.9) kg/m^2.

Exclusion Criteria: Subjects were excluded if they had traumatic conditions of the lower limbs, previous orthopedic disorders or neurological deficit of the lower limbs, previous surgery of the lower limbs, leg length discrepancy, any sensory problems, neuromuscular disease like multiple sclerosis, functional ankle instability, ligament sprain or flat foot.

87 Subjects were enrolled in the present study according the calculation of the sample size with effect size (ES) (0.38) and power of the test (0.8) and p value (0.05) using G* Power 3.1.9.2 software (Universities, Dusseldorf, Germany). Subjects were divided into three groups according to their body mass index with 29 subjects in each group; Group (A)(control group); females with BMI (18-24.9) Kg/m^2, Group (B) females with BMI (25-29.9) Kg/m^2 and Group (C) females with BMI (30-34.9) Kg/m^2.

Instrumentation:

Weight and Height Scale: Weight and height scale (health scale, made in China) was used to measure the weight and height of each subject. Weight in kilograms and height in centimeters to determine body mass index for each subject [8].

Biodex System 3 Pro Isokinetic Dynamometer: Biodex System 3 pro Isokinetic is valid and reliable designed to obtain different variables as torque, peak moment, angle of peak torque, ROM, angular position and proprioception [9].

Measurement Procedures: All subjects agreed to participate in the study by completing an informed consent form. Personal data (age, address, telephone and dominant leg), anthropometric measures "weight and height" and BMI were measured before starting the evaluation procedures.

Instrumentation / Subject Positioning:

- All measurements were carried out in one experimental session for each subject.
- The calibration of the dynamometer was performed according to the specifications outlined by the manufacturer's service manual [10].
- The dynamometer and chair rotation were adjusted to zero degrees (as dictated by the manufacturer).
- The dynamometer tilting was adjusted to zero degrees.
- The dynamometer orientation was adjusted to 90 degrees.
- The limb support set in place and the ankle attachment was fixed to the dynamometer so that the fulcrum of the dynamometer corresponded to the axis of the subject's ankle joint. The standard toe straps were used over the foot.
- The chair, dynamometer and the armrest height were adjusted according to the height of each subject (as dictated by the manufacturer).
- Be used for testing elevated by a support arm under the knee [11-13].
- Securing straps were also used at the knee and around the trunk [12].
- Uniform instructions were given to each subject about the isokinetic equipment and the study prior to testing. Participants were regularly instructed to keep their muscles relaxed during measurement.

Ankle Active Repositioning Accuracy Measurement:

- One commonly used method for testing joint repositioning was the assigned joint position test [14]. During this test, the joint was actively moved to a target position that was memorized by the subject. Then it was returned to the initial position. Thereafter, the joint was moved actively back to the target position.

- The subject data was entered into the computer program database. Test protocol set from the software program: proprioception unilateral protocol with ankle plantar / dorsiflexion, type of test was chosen (active repositioning test) with speed 30° / sec [15]. Three repetitions for each test with a rest period of 10 sec in-between each trial [16].
- Range of motion (ROM) was set (from 45° planter flexion to 20° dorsiflexion) using the control panel [17].
- The target angle was at 30° of plantar flexion the particular angle was chosen because it is commonly used in the relevant literature and also because it falls within the most usual ROMs utilized during sports activities.
- The subject was blindfolded to eliminate visual input.
- Prior to testing, each subject was given two test runs to familiarize herself with the procedures.
- Initially, the anatomical reference (target) angle (30°) was set, then the participant moved and hold at the starting angle (0) by using the hold/resume (HR) button. The tested limb was allowed to move to the target angle (30°) plantar flexion, actively by the participant then hold for 10 sec as a teaching process for the subject.
- Then the limb was allowed to return to the starting angle by the apparatus. The participant was allowed to the target angle (30°) plantarflexion actively. When the participant felt that she reached the target angle actively, the examiner stopped the apparatus using the HR button.
- Three trials were recorded, each beginning from the starting position/angle. There was a period of rest equal to 30 seconds between each trial and the other.
- An absolute angular error was recorded as the participant perceived the reference angle the mean angular differences of the three trials, between the target angle position and the participant's perceived end range position was recorded (in degrees) as the deficit in repositioning accuracy and was used in statistical analysis.

Data Analysis: Measured outcomes were checked for normality using Shapiro-Wilk tests, calculating mean & SD and drawing histogram. All measured variables showed a parametric distribution and so ANOVA test was used to compare between groups followed by Bonferroni Post hoc test for multiple comparisons if the ANOVA test was significant. Data were presented as mean and SD. The level of significance was set at the level of p value < 05. Statistical analysis was performed using the statistical package for social studies (SPSS) version 20 for windows.

RESULTS

There was no significant difference between groups concerning age and height (p value > 0.05) as shown in Table 1. The results of this study showed that there was a significant difference in active repositioning error among the three groups; normal, overweight and obese subject's p value was 0.001 as shown in Table 2.

Table 1: Descriptive statistics and ANOVA test for the demographic data for groups

Variables	(Group A) N=29	(Group B) N=29	(Group C) N=29	F value	P value
Age (Y)	25.3±4.8	25.5±4.9	25.9±5.7	0.117	0.889
Weight (Kg)	58.17±5.4	69.68±4.9	85.06±5.3	192.015	<0.001
Height (Cm)	160.9±4.6	160.17±4.3	160.3±3.9	0.262	0.770
BMI	22.4±1.9	27.1±1.2	33±1.7	288.543	<0.001

P: probability, *: significant, SD: standard deviation

Table 2: Mean and standard deviation values of active ankle repositioning error of the three groups:

Active repositioning error	Normal Mean± SD	Overweight Mean± SD	Obese Mean± SD	F value	P value
	4.9±2.9	7.7±4.6	9.7±6.1	7.374	0.001*

P: probability, *: significant, SD: standard deviation

Table 3: Multiple pairwise comparison tests (post hoc test) of ankle active repositioning error:

		95% Confidence Interval	
Ankle active repositioning error	P value	Upper limit	Lower limit
Normal Vs Over Weight	0.084	0.25	-5.85
Normal Vs Obese	0.001*	-1.72	-7.83
Over weight Vs Obese	0.351	1.07	-5.03

P: probability level, *: significant, Vs: versus

The pairwise comparison revealed a significant difference in ankle active repositioning error between normal subjects and obese subjects with p value 0.001 as shown in Table 3. However there was no difference in ankle active repositioning error between normal and overweight subjects and between overweight and obese persons (p value 0.084 and 0.351) respectively as shown in Table 3.

DISCUSSION

In this study, the influence of body mass index on ankle proprioception in adult females was studied.

Proprioception has the main role in balance control and ankle proprioception is the most important aspect in controlling balance. Central processing of the ankle proprioceptive information, along with other sensory information, enables the integration of postural and balance control [18].

To control upright posture, the brain needs to correct small deviations from an upright body position to reduce the consequence of the gravity induced torque that tends to accelerate the body further away from the upright position. To counter the destabilizing torque, a corrective torque is exerted by the foot and ankle against the support surface [19].

There is evidence suggesting that visual, vestibular and ankle proprioception contribute to postural control. For instance, various studies have demonstrated that either stimulation or reduction of the cue, to the planter sole mechanoreceptors or ankle proprioceptive system evoke body sway [20].

Obesity is the main risk factor for large joints disorders, intuitively, it would seem likely that obesity greatly increases the biomechanical loads involved in walking. Obese adults experience a greater rate of joint loading. Obesity decrease postural and balance control as its effects on Joint proprioception [21].

The result of this study demonstrated that increased body mass index had a significant effect on ankle proprioception in adult females. Obese individuals experience greater absolute loads at the ankle joint than individuals of normal weight. Therefore, the function of the proprioceptors in the ankle joint is affected due to greater loading [22].

Different theories could explain these proprioceptive deficits in obese subjects; the first is that skin stretching resulting from excess adiposity may increase the distance between the cutaneous mechanoreceptors and this may lead to decrease the discrimination threshold of somatosensory perception [23]. Also, it has shown that the limited physical activity, as reported in obese patients, contributed to the alteration of the body schema [24].

Body schema is built on the basis of multisensory inputs including cutaneous and proprioceptive receptors with obesity, these receptors may provide altered information to the somatosensory cortical area altering, in turn, the obese patients' body schema representation [1].

The second explanation is that increased subcutaneous layer of fat tissue or a pathological alteration of the nerve fibers due to the reduced insulin sensitivity in obese individuals may impair the sensory transmissions [25]. It was showed that obesity impairs motor and sensory nerve conduction velocity [26]. In addition, other studies have shown that sensory and motor threshold is higher in obese than nonobese subjects. This means a threshold stimulus would affect afferent input from the body and efferent response from the neuromuscular system (sensorimotor integration) which might affect the proprioceptive system [27].

Poor postural stability in obese individuals in comparison to normal subjects might give a clarification of the finding of the present study [28].

The current finding was supported by Christine and Hui-chen finding as they examined the effect of ankle joint proprioception and postural control in basketball players with bilateral ankle sprains, they found a positive relationship between ankle average errors in ankle joint repositioning and amount of postural sway instance, and noticed a decrease in postural control had been detected in subjects with a loss of joint proprioception [29].

The current results also were supported by Simoneau and Teasadale study as they studied the balance control impairment in obese individuals caused by larger balance motor commands variability, they found balance control and ankle proprioception impairment, observed in obese individuals compared to lean individuals. They noticed that obese individuals could rely more on visual and vestibular information to control balance [30].

Another study confirmed the current findings as it examined the effect of improving postural instability of extremely obese individuals after a bodyweight reduction program entailing specific balance training. It was found that postural stability was poorer in extremely obese individuals as compared to their normal weight counterparts, mechanoreceptors found in the plantar surface of the foot and musculature about the ankle and the joint would have played a role in the difference between obese and nonobese [28].

Moreover Hills and parker reported a deficit in postural stability and proprioception acuity in obese children [31]. Another study concluded that body weight is a strong predictor of postural stability [32].

On the other hand, a study done by Wang *et al*., examined the proprioception of ankle joint in obese boys and nonobese boys, it was found that there was no significant result in ankle proprioception [1].

In contrast to the present study, another study investigated the influence of age, body mass index and leg dominance on functional ankle stability and it was found that ankle proprioception was not influenced by age, BMI or leg dominance [33].

CONCLUSIONS

Obese adult females have deficit on their ankle proprioception.

Limitations: Although the current study reveals objective data with statistically significant differences, there are some limitations. This study was limited to that ankle prorprioception measurements were taken from the sagittal plane only (Dorsiflexion and planterflexion). Measurements from other planes (Transverse and Frontal) were not taken.

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