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RESEARCH ARTICLE

Comparison of the upper extremity and lower extremity coordination in normal and obese children aged 9-12 years - A cross-sectional study

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Abstract: *Background:* This study aimed to compare upper and lower extremity coordination in normal and obese children and to establish a relationship between motor coordination and BMI. *Methods:* Data were collected from 100 children aged 9 to 12 years. BMI was calculated, and participants were divided into two groups: normal (n1 = 50) and obese (n2 = 50). Both groups were assessed for motor coordination: the Plate Tapping Test (PTT) for upper extremity coordination and the Lower Extremity Motor Coordination Test (LEMCOT) for lower extremity coordination. The time to complete PTT and the number of taps in LEMCOT were recorded. *Results:* A statistically significant difference in motor coordination scores was observed between the two groups. Additionally, a strong negative correlation was found between BMI, PTT, and LEMCOT scores in the obese group. *Conclusion:* Our study demonstrated that obese children of both sexes have significantly lower motor coordination than normal-weight children, with an inverse relationship between motor coordination and BMI in the obese group.

Keywords: *Motor coordination, Obesity, Body mass index, Adolescents, Correlation, Children*

Introduction

Obesity in children is among the world's biggest public health problems, and the formative years of life are crucial for the development of overweight and obesity. According to the World Health Organization, the prevalence of overweight and obesity in children and adolescents has been rising quickly, and there will be about 70 million overweight or obese children by 2025.[1] The high prevalence of obesity is linked to a higher risk of developing certain medical conditions, including stroke, insulin resistance, and systemic arterial hypertension.[2] Apart from these conditions, obesity may also affect physical attributes such as gross motor coordination and motor performance, as these traits appear to be closely linked to children's and adolescents' regular physical activity and body composition.[3]

Literature has explored the potential relationship between adherence to physical activity during adolescence and gross motor coordination. Motor coordination refers to the coordinated interactions between the nervous, skeletal, and sensory muscle systems, which are required to produce precise motor actions and

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quick reactions to everyday situations. This involves the proper development of muscle strength and the targeted selection of muscles that control the movement's performance. [4] Motor skills are a set of coordinated movements that children learn in their early years, encompassing object control and locomotor skills. They are obtained through the physiological maturation of the neuromuscular system and environmental factors. [5] The body can move through space by using locomotor skills, which include running, galloping, and jumping. The ability to manipulate and project objects in various ways, such as throwing, catching, dribbling, kicking, hitting, and rolling, is known as object control. [6] Notably, the programming of physiological systems in adult life may be correlated with motor performance during childhood and adolescence. Better performance in gross motor coordination and engagement in physical activities have been positively correlated. Lubans [7] in his recent review on the connections between motor coordination (MC) and health benefits stated that individuals' motor coordination levels are inversely correlated with weight status. Stodden et al. [8] suggested that low MC will cause adolescents to fail at sports and movement play activities in adulthood, setting off a vicious cycle of disengagement from an active lifestyle. Due to the increased difficulty of physical activity, it is plausible that kids and teenagers with low gross motor skills will not want to engage in it. It is also conceivable that sedentary pursuits, such as watching TV and playing computer games, would appeal to kids with limited gross motor skills. Evidence suggests that regardless of gender or baseline body mass index, children who develop physical fitness and motor competence at a slow or medium pace are more likely to become overweight or obese by the end of primary school. [9]. It is also important to understand the connection between overweight and obesity in children and their motor development. [10],[11],[12] Therefore, the present study aimed to compare the upper extremity and lower extremity coordination in normal and obese children and establish a relationship between motor coordination and body mass index in children aged 9-12 years.

Methodology

Before the study commenced, approval was obtained from the Institutional Research Committee, and the study was conducted by the STROBE checklist. A cross-sectional design with convenience sampling was employed, and the sample size (n = 100) was calculated using the formula $n = (z1- \alpha/2^2P(1- P)/d^2)$, where the prevalence of obesity was considered to be 19.3%. Participants were boys and girls aged 9-12 years, with BMI scores ranging from the 5th percentile to less than the 85th percentile, and from the 95th percentile and above. Children with corrected vision and hearing were also included in the study. Children enrolled in competitive sports under a professional trainer or those with any neurological, musculoskeletal, cardiorespiratory disorder, or medical and surgical condition were excluded from the study. The participants have explained the study procedure, and a consent form was obtained from a parent/teacher, and an assent form was obtained from the child. The body weight was calculated using a digital weighing scale, and the participant was asked to stand erect without footwear and empty pockets. The stature was measured using a stadiometer, for which the participant stood erect, touching their heels to the wall, and without footwear. The BMI was calculated, and children were stratified into normal ($n1=50$) and obese groups ($n2=50$) using the Centers for Disease Control and Prevention Guidelines (CDC). [13],[14] Each group underwent upper and lower extremity coordination tests.

Procedure to assess upper extremity coordination using Plate Tapping Test [15]

The plate tapping test is a valid and reliable method for assessing upper extremity coordination. The apparatus of the plate tapping test included two yellow-colored paper discs of diameter 20 cm, placed (60 cm) apart from their centre point, and a blue-colored rectangle (30x20cm) placed between the two discs at an equal distance. All this was mounted on a sheet of cardboard. The child was standing erect in front of the table, placing their non-preferred hand over the blue rectangle cut out, and their preferred hand relaxed beside their body. Upon the command "to start," the participant moved their preferred hand back and forth, alternately tapping 25 times over each disc, and the time for this action was recorded using a stopwatch. Before the actual test, a short practice session of 4-5 taps was given.

Procedure to assess lower extremity coordination using LEMOCOT [14]

The LEMOCOT is a valid and reliable tool to assess lower extremity motor Coordination. The test was conducted using a chair with a backrest featuring two red-colored discs of 6 cm diameter, which were placed 30 cm away from their center. The child was seated in a comfortable position on a chair with knees flexed at 90°, with the great toe over the proximal target. They were instructed to alternately touch the distal and proximal targets with the great toe (hallux) for 20 seconds, which was observed using a stopwatch/phone. The total number of taps was counted. Before the actual test, a practice of 4-5 taps was given.

Results

Data were coded, compared, tabulated, and analyzed using the Statistical Package for the Social Sciences (SPSS version 24). The Mann-Whitney U test was performed to compare the median values, and a p-value of <0.05 was set as the statistical significance threshold. Table 3 provides descriptive statistics for age, gender, hand dominance, and BMI for normal and obese groups. Tables 4 and 5 present the median scores of the normal and obese groups for the Plate Tapping test and LEMOCOT, respectively. Table 6 represents the correlation between BMI and PTT and LEMOCOT in the normal and obese groups.

Table 3: Demographic details of the participants

Variables	Normal (n1=50)		Obese (n2=50)	
Age (years)	11.50± 0.505		12.32± 0.471	
Gender n(%)	Boys 25(50%)	Girls 25(50%)	Boys 28(56%)	Girls 22(44%)
Hand dominance	4 left (8%) 46 right (92%)		4 Left 8% 46 Right 92%	
Body Mass Index (kg/m^2)	15.99±1.493		23.72± 2.1076	

Table 4: Median scores of PTT

Plate tapping test	Normal (n1=50)	Obese (n2=50)
Median	21.31(20.55, 25.31) sec	30.1(28.15, 32.39) sec
Mann-Whitney U	1125	
p-value	0.05*	

**Significance was considered at p<0.05*

Table 5: Median scores of LEMOCOT

LEMOCOT	Normal (n1=50)	Obese (n2=50)
Median	23 (21.01, 29.25) taps	32 (23.75,33) taps
Mann-Whitney U	1064	
p value	0.02*	

**Significance was considered at p<0.05*

Table 6: Correlation of BMI with PTT and LEMOCOT in the normal and obese group

Spearman's Rank Correlation	PTT	LEMOCOT	p-value
Normal BMI	0.00	0.0	0.08
Obese group	-0.65	-0.68	0.00*

**Correlation is significant at the 0.05 level (2-tailed).*

Discussion

The present study aimed to compare upper and lower extremity motor coordination in normal-weight and obese children aged 9-12 years. There was a statistically significant difference between the median values of PTT and LEMOCOT for both groups. Normal-weight children could perform the PTT within a shorter time and with more taps in LEMOCOT than obese children. Obesity is associated with the accumulation of visceral body fat and is associated with low-grade inflammation in young obese children. Inflammatory responses activated in the body promote obesity-driven dysfunction that affects the nervous system, including alterations in learning and memory, axonal degeneration, and Schwann cell dysfunction. [16],[17] Muscle strength is altered by fat accumulation in the muscle, which makes the muscle stiffer and resists muscle shortening and its transverse bulging. [18] Another reason why the obese group in our study took a longer time to complete the PTT and a lesser number of taps in LEMOCOT we attribute to findings by Bushbacher [19] who stated that sensory-motor latencies of the peripheral nerves in the upper limb and lower limb and sensory latencies were increased in obese Indian individuals as compared to healthy control due to endoneurial edema of the peripheral nerves due to the metabolic effect of obesity.

Our study also found moderately negative correlations between MC and BMI. Additionally, compared to children of normal weight, the data show significantly poorer MC for obese children of both sexes. According to Onur Akin [20], obese children may have peripheral sensory and motor nerve pathology when compared to normal healthy children, and a more significant difference was obtained in obese children with insulin resistance. Due to high insulin concentration, the receptors undergo downregulation, leading to dysfunction, as insulin is essential in the mechanisms of synapse formation, nerve regeneration, neural plasticity, gene expression, neurotransmitter production, and myelination. Hyperinsulinism and resistance to it cause basal membrane dysfunction, leading to obstruction in the vasa nervorum, reduced endoneurial perfusion, and hence axonal degeneration. [21]

Puberty-related changes occur in the age range of 9-12 years, which influences motor coordination based on the intensity of the growth spurt and biological age, and this may have also impacted the outcome of our study. [22][23] At any age, the connection between motor coordination (MC) and BMI may also be impacted by the additive effects of increased weight on MC. These proposed positive or negative spirals of MC reinforcement, which could indirectly result in long-term changes in body composition throughout childhood, are similar to the stronger negative correlation values we observed in our data. [24] Overall, our study findings are consistent with most other studies, which show a negative correlation between childhood body weight status and various measures of coordination. Our study had limitations; however, we are unable to conclude the causality of the relationships between BMI and coordination due to the cross-sectional nature of the data. Furthermore, body fat percentages cannot be most accurately predicted by BMI. Additionally, a more thorough MC assessment might offer a better understanding of how MC and body composition trajectories change over time.

Conclusion

Our findings support the hypothesis that children and adolescents who are obese perform poorly on tasks requiring motor coordination. Therefore, it is essential to prevent childhood obesity, reduce the weight of affected children, and promote physical activity.

Ethical consideration

The IEC approved this study, vide letter no. MGM/COP/IRRC/8/2022, dated 14/07/2024.

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Conflicts of interest

There are no conflicts of interest.

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