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Percentile Values of Selective Motor Control of Upper & Lower Extremities in Healthy Children

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DECLARATIONS

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ABSTRACT

Background: The ability to isolate the activation of muscles in response to the demand of a voluntary movement is known as Selective voluntary control. These movements require coordination and precision to adapt to a particular situation depending on the information provided by the senses; therefore, these voluntary movements are responsible for maintaining posture and locomotion. The selective voluntary controlled movements are assessed through performing the reciprocal movements at various joints. **Objective:** To find the percentile values of upper and lower limbs among the healthy children population. **Methodology:** A descriptive cross-sectional survey was conducted within 6 months after approval of the synopsis, including 400 participants using convenient sampling. Both boys and girls between the ages of 4 and 14 years were included. Children were excluded if they had any neurological diseases, including cerebral palsy, or had undergone surgery or structural deformities, acute injuries, or congenital disabilities. The test of arm selective control is a clinical scale used to assess upper extremity movements, where motion at each of the five joints is graded on a three-point scale. Similarly, the selective control assessment of the lower extremities is a three-point clinical tool designed to evaluate selective voluntary motor control of the lower extremities. Quantitative variables were presented as mean and standard deviation. While the qualitative variables were presented as frequency and percentage, and bar charts. **Results:** Regression analysis of selective motor control of the upper and lower limbs with gender represents a weak positive correlation (0.106). Therefore, the regression analysis of body mass index and age reveals a negative correlation (r=-0.44). The analysis of variance statistics depicts that the selective motor control of the limb is independent of body mass index. **Conclusion:** The study developed a percentile value normative data of healthy children in the age group 4 to 14 years. An insignificant correlation between gender and body mass index was found.

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INTRODUCTION

Selective motor control (SMC) refers to the capacity to specifically activate certain muscles in a chosen pattern to perform a voluntary movement, ultimately to maintain and achieve a particular posture.[1] It helps perform various daily living activities (ADLs) such as grasping, reaching, writing, running, and walking.[2] A study of reference has quantified the selective voluntary control movement (SVCM) objectively through three procedures: clinical assessments, EMG, and computer games. Therefore, SVCM is directly linked in proportion to the age of the child, apart from any impairment or neuromotor disorders. In addition, experimental studies have shown intersegment coordination developed in children via postural kinetics.[3]

During childhood, postural kinematics undergo significant changes as the child grows and develops. [4] As they develop further, they learn to maintain postural stability while walking and develop more postural adjustments in response to different tasks.[5] Studies have shown that children with developmental coordination disorder DCD have difficulties with postural kinematics, including slower and less precise movements, difficulty adapting to changing environments, and less efficient control strategies.[6] These difficulties can affect a child's potential to perform ADLs.[7] When we study the emergence of SCVM, it is important to understand two major expects of movement that are via the central nervous system (CNS) or the biomechanical structure of the body.[8]

The CNS controls the isolation of movements through the use of specific neural pathways that allow for the activation of specific muscle groups while inhibiting others.[9] Various studies have verified that in the absence of sensory input, the self-contained nervous system can generate a regular pattern of motor activity.[10] Impairments of the CNS can lead to difficulties with the isolation of movements. These conditions can affect the neural pathways involved in the control of movement or difficulty with isolating specific movements.[11] The test of arm selective control (TASC) is a clinical assessment tool intended to evaluate selective control of the upper extremity in the population diagnosed with neurological impairments such as stroke, traumatic brain injury, and cerebral palsy.[12] The TASC is a standardized assessment tool that has been used in healthcare practice and experimentation to assess the efficacy of interventions targeting the enhancement of arm function of individuals with neurological impairments.[13]

Research has shown that typically developing children acquire selective voluntary control of their movements gradually over time. As children continue to grow and develop, their ability to isolate and control specific muscle groups improves. This is reflected in the development of more complex motor skills such as fine motor coordination and balance.[14] The percentile values of both limbs among healthy individuals can vary depending on various factors such as age, gender, height, weight, and overall health status. In general, the percentile values for limb measurements are determined by comparing the measurements of an individual to a reference population of the same age and gender.[15]

Veiluf et al (2023) have shown that SVMC develops gradually over time and is closely linked to the maturation of the nervous system. For example, a study found that children as young as 4 years old could exhibit SVMC in their fingers, but that this ability continued to improve throughout childhood and adolescence.[16] Cullen KE et al study shows that body position can affect SVMC. For example, a study found that children had better SVMC in seated positions compared to standing positions.[17] A study by Sukal-Moulton et al was on cerebral palsy (CP) children for the lower extremity of maximal voluntary isometric contraction in contrast to prime movers and non-prime mover muscles. Such an understanding may help in identifying effective strategies for improving muscle control in children with CP.[18]

JR Magnuson et al (2023) proposed an article that states that individuals with CP may possess difficulty with SVC due to anomalous divergent or disfigurement in the parts of the cerebrum that control movement. This can result in a range of motor impairments, including spasticity, stiffness, and lack of coordination.[19] Diaz et al (2019) studied, the determination of percentile values is crucial for tracking a child's motor development. These values show how a child's talents and abilities stack up against those of their contemporaries in the same age group.[20] There is currently a gap in the literature regarding SVC and percentile values among healthy children. While there have been studies on motor development and function in Pakistani children. Research on motor development and function in Pakistani

children has generally focused on gross motor skills and has shown that children in Pakistan tend to have lower motor skills compared to children in other countries. However, there is limited research specifically examining fine motor skills and SVC in Pakistani children. So by the review of the literature it has been notified there is a great lack and gap of study on a normal population of children the current study aimed more specifically Lahore general population and yet so far there is no noticeable percentile value data to demonstrate the selective motor control of upper and lower extremity particularly among Pakistani healthy children.

METHODOLOGY

The setting of this descriptive cross-sectional survey was at Riphah University, Lahore, and the data were collected from the general community. The duration of the current study was six months after the approval of the synopsis. The sample size was calculated as 400 participants using convenient sampling.[21] The study included both male and female participants aged 4 to 14 years.[22] Only healthy children were considered eligible, specifically those who were functionally mobile and able to follow commands.[20]

Children were excluded from the study if they had any neurological diseases, including cerebral palsy, or had undergone surgical treatment within the last six months,[23] structural deformities such as genu valgum, genu varum, scoliosis, or torsional deformities.[24] Additionally, children with acute injuries preventing limb movement, and congenital disabilities like leg length discrepancy, clubfoot, cleft foot, or femoral anteversion were not included.[25] A history of any communicable disease, abnormal muscle tone, restrictions in physical activity, or impaired strength in the upper or lower extremities was also considered as exclusion criteria.[26]

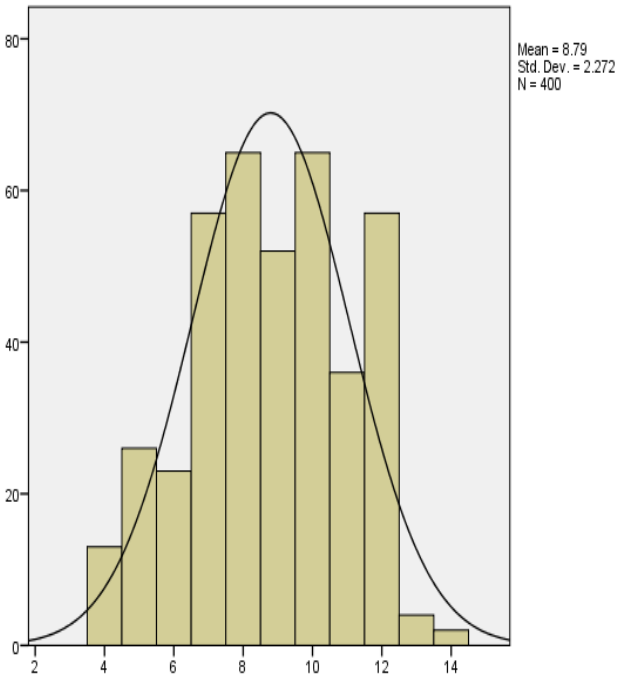
The TASC is a clinical scale used to assess upper extremity movements, where motion at each of the five joints is graded on a three-point scale.[27] Similarly, the selective control assessment of the lower extremity (SCALE) is a three-point clinical tool designed to evaluate selective voluntary motor control of the lower extremities, particularly in individuals with spastic cerebral palsy.[28] Consent was taken, and participants were informed of the purpose of the measurements. All the participants were assessed for the eligibility criteria. Therefore, the data was collected from the children who had never undergone any surgical intervention and lacked any disease or deformity.

Data analysis was carried out on SPSS version 27. Quantitative variables were presented as mean standard deviation and histograms. Whereas, qualitative variables were presented as frequency and percentage, and bar charts. The study analyzes to determine correlations and uses regression analysis to evaluate the relationship between the variables.

RESULTS

The study included 400 children aged 4 to 14 years, with 190 males and 210 females. The mean age was 8.79±2.27 years, and left upper limb joint ROM values were consistent, ranging from 1.98 to 1.99 with minimal variation (Figure 1). Right upper limb joint ROM values also remained stable, mostly between 1.98 and 1.99. Similar consistency was observed in the left lower limb joints, including the hip, knee, ankle, and toes. Right lower limb ROM values were nearly identical to the left, with most measurements close to 1.99. Subtalar and toe joint scores showed little variation across a significant correlation between gender and joint scores ($p<0.05$), with a weak positive correlation ($r=0.10$) and an insignificant negative correlation uniformly 2.00. Statistical analysis showed no correlation between age and BMI ($r=-0.44$).

Figure 1: Age of participants (years)



DISCUSSION

The survey targeted children aged 4 to 14 years, aiming to provide valid statistical percentile data. Upper and lower extremity joints were assessed using established tools: the TASC for the upper limb and the SCALE for the lower limb. Specific patterned joint movements were evaluated to validate selective motor control. Participants were selected based on clearly defined inclusion and exclusion criteria. The research findings showed that all four key percentiles (25th, 50th, 75th, and 100th) consistently scored two for both upper and lower limbs. This uniform scoring suggests strong and reliable selective control across the sampled population. Overall, the study confirms the effectiveness of TASC and SCALE in assessing motor control in healthy children.

Studies suggest that while BMI and gender affect overall physical health, they do not directly impact selective voluntary control. This ability depends more on neuromuscular coordination, motor learning, and specific training. Recognising this helps tailor interventions to improve motor control across different BMI groups.[29] Normal healthy children have complete control of movements and have a greater ability to perform isolated movements even when they are sleeping. A study surveyed the periodic limb movements among healthy children aged 5 to 15 years while asleep, and the results showed that the movements were infrequent.[30]

The study focuses on the normative percentile values of data among healthy children of upper and lower limb joints and the impact of selective motor control movement on the age, gender, and BMI variables.[31] While the previous studies showed a reliable accountancy of percentile normative data but usually among the non-healthy population, and to a lesser extent over the healthy population. In the current study, it has been proven that percentile values among healthy children have a score of two at a greater probability, with a mean and standard deviation of 1.99±0.09. This study was conducted over a smaller area, and its authenticity may be verified if the territorial area expands. This study justifies that there is no particular association of BMI and age with gender while performing any selective control movement. The participants of the study also did not differ across gender in selective motor control of bilateral joints of the upper and lower limbs.[6]

CONCLUSION

The study developed a percentile value normative data of healthy children in the age group 4 to 14 years. An insignificant correlation between gender and BMI was found, according to the investigation. According to the study's findings, joint scores in this age group are not significantly impacted by gender.

DECLARATIONS

Consent to participate: Written consent had been obtained from patients. All methods were performed following the relevant guidelines and regulations.
Availability of data and materials: Data will be available on request. The corresponding author will submit all dataset files.
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