Impact of muscular strength in children with autism spectrum disorder: a comparative study[1]

Impacto da força muscular em crianças com transtorno do espectro autista: um estudo comparativo

Impacto de la Fuerza Muscular en Niños con Trastorno del Espectro Autista: Un Estudio Comparativo

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Abstract

Limited research has explored the relationship between muscle strength and ASD within pediatric populations, and this forms the primary focus of the current investigation. This study assessed muscle strength in children aged 4 to 7 years, comparing those with ASD (n=34) to those without ASD (n=52). Grip strength and isometric strength of the knee extensor muscles were measured using standardized tests. Ethical considerations were followed, and statistical analysis was performed using IBM SPSS Statistics 25.0. Children with ASD demonstrated significantly lower grip strength and knee extensor muscle strength compared to those without ASD ($p < 0.05$). These findings suggest a negative influence of ASD on muscle strength, potentially impacting functional abilities and quality of life. The study suggests that children with ASD exhibit lower muscle strength compared to their peers without ASD.

Keywords: autism spectrum disorder, muscle strength, pediatric populations, motor abilities.

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Resumen

La investigación limitada ha explorado la relación entre la fuerza muscular y el TEA en poblaciones pediátricas, lo cual constituye el enfoque principal de la presente investigación. Este estudio evaluó la fuerza muscular en niños de 4 a 7 años, comparando aquellos con TEA (n=34) con aquellos sin TEA (n=52). Se midió la fuerza de agarre y la fuerza isométrica de los músculos extensores de la rodilla mediante pruebas estandarizadas. Se siguieron consideraciones éticas y se realizó un análisis estadístico utilizando IBM SPSS Statistics 25.0. Los niños con TEA mostraron una fuerza de agarre y una fuerza de los músculos extensores de la rodilla significativamente más bajas en comparación con aquellos sin TEA ($p < 0.05$). Estos hallazgos sugieren una influencia negativa del TEA en la fuerza muscular, lo que podría afectar las capacidades funcionales y la calidad de vida. El estudio sugiere que los niños con TEA presentan una fuerza muscular más baja en comparación con sus pares sin TEA.

Palabras clave: trastorno del espectro autista, fuerza muscular, poblaciones pediátricas, habilidades motoras.

Introduction

Muscle strength is an essential characteristic in human development that involves muscle tension against a certain resistance, resulting in physical adaptations that maintain the body's homeostasis (Guyton & Hall, 2017). In the context of childhood muscular development, neuropsychomotor differences can affect motor performance, especially when comparing children with Autism Spectrum Disorder (ASD) to children without ASD (Emanuele et al., 2021). Therefore, various motor tasks, including resistance exercises, have commonly been used to alleviate ASD symptoms, improve social interaction and motor skills, and enhance focus and concentration (Cavallo et al., 2021; Lima et al., 2020).

ASD is characterized by neurodevelopmental alterations that have deleterious effects on communication and social interaction abilities, as well as the presence of restricted interests and repetitive behaviors (Emanuele et al., 2021; American Psychiatric Association [APA], 2022). Moreover, children with ASD often show lower levels of muscular strength and functional capacity when compared to children without ASD (Ludyga et al., 2021). Additionally, it should be emphasized that deficits in certain executive functions such as working memory and problem-solving can coexist (Ludyga et al., 2021).

In this context, the global increase in the prevalence of ASD has highlighted studies aimed at analyzing the relationship between ASD, muscular strength, body mass index (BMI), and executive function in children and adolescents with ASD (Ludyga et al., 2021). Furthermore, it is pertinent to emphasize that in children with ASD, reduced communication capacity associated with low social interaction can have negative effects on locomotion and motor skills (Mejía et al., 2020).

Therefore, some studies show that different training methods, including strength training (ST), can positively influence muscular strength performance and the learning of motor tasks that require focus and attention, as well as improve social interaction in children with ASD (Kokaridas et al., 2018; Ludyga et al., 2021). Additionally, some recent scientific evidence elucidates that resistance exercises, when performed in water, can positively interfere with physical fitness and muscular strength performance in children with ASD (Battaglia et al., 2019; Guerra et al., 2019).

Furthermore, it is important to emphasize the significance of engaging individuals with ASD in regular physical exercise programs, given that individuals with ASD commonly exhibit higher levels of sedentary behavior (Adin & Pancar, 2023; Must et al., 2015). However, it should be noted that the scientific literature is scarce regarding the measurement of muscular strength in children with ASD. Since muscular strength is correlated with health indicators and consequently quality of life, it is extremely relevant to analyze this physical component in children, particularly in children with ASD. This research could contribute to the enhancement of physical exercise programs offered to the population of children with ASD. Thus, the aim of this present study was to assess muscular strength performance in children with and without ASD. We hypothesized that muscular strength in children without ASD is greater than in children with ASD.

Methodologies

Sample

The sample consisted of 86 children of both sexes, aged between 4 and 7 years old. A total of 86 children from the Olympic Villages of the City of Rio de Janeiro were evaluated, selected randomly. There were 34 children with ASD and 52 children without ASD. All children with ASD were required to have a confirmed diagnosis through a medical report. The sample selection procedure initially adhered to the following inclusion criteria: absence of bone, muscle, and/or joint injuries that would be limiting for the execution of movements, age between 4 and 7 years old, signature of the Informed Consent Form (ICF) by the legal guardian, and signature of the Informed Assent Form (IAF) by the child. Children who met any of the following points were excluded from the study: children who, for any reason, experienced pain or movement limitations, children who couldn't establish initial understanding and couldn't perform the tests (especially children with ASD), and children who didn't complete all the tests.

To characterize the sample, measurements of body mass (kg) and height (cm) were taken using the following instruments, respectively: Avanutri digital scale (Brazil) AVA – 340, total capacity: 180 kg, graduation: 100g; and portable stadiometer Avanutri (Brazil) AVA – 305, measurement range: 20cm to 210cm, graduation: 0.1cm.

Ethical Considerations

The research was submitted to the Research Ethics Committee of the Federal University of the State of Rio de Janeiro (CEP-UNIRIO) to ensure compliance with the ethical principles concerning human subjects, as defined by Resolution 466/12 of the National Health Council (196/69) regarding research ethics. It was registered and approved under the number CAAE: 45226621.8.0000.5285.

Data Collection Procedures

Hand Grip Strength (HGS)

Hand grip strength (HGS) was measured using a manual dynamometer Camry (Brazil), model EH 101. This instrument features 5 levels of grip adjustment, and grip level 2 was used to best fit the children's hands. It's important to highlight that the dynamometer reading is not subjective; it measures force in kilograms or pounds, with a range up to 90 kg/198 lb and a scale increment of 100g/0.2 lb. This study used kilograms.

Furthermore, the current test included two familiarization sessions where participants were introduced to the instruments and instructed on how to perform the test, thereby minimizing potential errors. The test was carried out alternately by both hands, with 3 attempts for each side and a minimum interval of 30 seconds between them to prevent fatigue. The best result from each hand was recorded. These measurements were taken after a wrist joint warm-up session, along with 5 submaximal contractions using the device itself. Kern et al. (2013) describe that multiple attempts are the standard when using a manual dynamometer, particularly when applied to children. Additionally, participants positioned themselves according to the recommendation of the American Society of Hand Therapists (1992): seated with hips and knees at 90º flexion, shoulder in adduction, elbow flexed at 90º, forearm and wrist in neutral position, and they were encouraged to give their maximum effort. The evaluator supported the dynamometer during the test execution.

Isometric Lower Limb Strength

The test was performed with the individual seated on a bench or chair. The dynamometer was attached to the individual's leg using a Velcro ankle strap positioned just above the ankle. Participants were instructed not to make compensatory movements during the test; however, the evaluator was instructed to physically restrain such movements if they occurred. A hip flexion of approximately 90º and a knee flexion of 70º were sought, considering 0º as the neutral hip position and full knee extension (de Vasconcelos et al., 2015; Machado et al., 2022). After a warm-up of 10 repetitions of knee extension with body weight only, with free amplitude, the test followed. Three maximum isometric contractions were performed, always with verbal encouragement provided by the evaluator, such as "stronger" and "push your foot against my hand." A one-minute interval was given between repetitions, and the best score obtained was recorded.

Additionally, the portable dynamometer E-lastic® (Brazil) has a capacity of 200 kg. The measurement is carried out by a load cell AEPH do Brasil®, model TS 200. Along with the load cell, there is a digital interface in the form of a mobile application (E-lastic 5.0, compatible with Android and iOS operating systems) that captures force data from the force sensor and transmits force information in kilograms (kg) to the application using Bluetooth® technology (BLE, 4.0). The smartphone used was a Samsung Galaxy S21 Plus (Brazil) running the Android 11 Samsung One UI 3.1 operating system.

Normalization by allometric scaling

With the aim of reducing the bias related to the influence of body mass on muscle strength, muscle strength was normalized using an allometric scale, where this approach is more accepted for data normalization by removing the direct influence of body size. Allometry provides a more effective method for standardizing performance control of body dimensions than ratio scaling (Oba et al., 2014; Crewther et al., 2019). To perform the normalization, the following equation was used:

$$\mathbf{MSc = MSa/BM^{b}}$$

Where MSa: Absolute muscular strength, MSc: Corrected muscular strength, BM: body mass and b: allometric exponent.

In brief, the value of the allometric exponent (b) can present a large variation, where the type of force manifestation (isometric, concentric and eccentric) directly influences. The scientific literature suggests that in muscular strength exercises that require overcoming external resistance, such as: hand grips, squats, bench presses, biceps and triceps curls, generally have allometric exponents of approximately b=0.67. Consequently, for this research the value of b=0.67 was used.

Statistical Analysis

The null hypothesis was that children with ASD would have similar levels of muscle strength compared to children without ASD. The statistical analyses were conducted using the IBM SPSS Statistics 25.0 program for Windows. The Shapiro-Wilk test was employed to assess the normality of data distribution, and normality was confirmed for all variables. An independent samples t-test was utilized to compare muscle strength between the groups. A significance level of $p<0.05$ was adopted for all statistical analyses to determine statistical significance.

Results

In this section, we present the detailed outcomes of the research that aimed to compare the muscle strength of children with ASD to children without ASD. The meticulous quantitative analysis of strength measurements provided valuable insights into potential differences in muscle strength and functionality associated with ASD.

The sample consisted of 86 children aged between 4 and 7 years, divided into two groups: the Autism Spectrum Disorder group (ASD group), comprising children diagnosed with ASD, totaling 34 children, and the Non-ASD group, consisting of children without an ASD diagnosis, comprising 52 children. Table 1 presents the mean and standard deviation values of the sample characteristics.

Table 1 - *Sample Characterization*

Groups	Mass (Kg)	Height (cm)	Age (anos)
ASD	22.71 ± 6.26	116.09 ± 6.82	5.24 ± 0.99
Non-ASD	20.61 ± 4.75	109.25 ± 6.01	5.79 ± 0.96

Legend: ASD = Children with Autism Spectrum Disorder; Non-ASD = Children without Autism Spectrum Disorder. Note: self-elaboration

It can be observed in Table 1 that both groups showed no significant differences in body mass, height, and age ($p > 0.05$); however, children with ASD are taller and heavier when compared to children without ASD.

Table 2 provides the mean and standard deviation values of HGS and maximum isometric strength (MIS) of the knee extensor muscles for both limbs, after normalization by allometry. As a result, significant differences were observed in the HGS of the right limb ($p < 0.01$; 95% CI = 0.17 to 0.38; t = 5.28; df = 84), HGS of the left limb ($p < 0.01$; 95% CI = 0.17 to 0.39; t = 5.25; df = 84), MIS of the right knee extensor muscles ($p < 0.01$; 95% CI = 0.10 to 0.35; t = 3.67; df = 84), and MIS of the left knee extensor muscles ($p < 0.01$; 95% CI = 0.14 to 0.40; t = 4.26; df = 84) when comparing children with and without ASD.

Table 2 - *Mean and standard deviation values of HGS and MIS of the knee extensor muscles for both limbs after normalization by allometric scaling.*

	ASD	**Non-ASD**	**p Value**
HGS (Right)	0.80 ± 0,27	1.08 ± 0.22	< 0.01*
HGS (Left)	0.74 ± 0.25	1.01 ± 0.22	< 0.01*
MIS (Right)	1.00 ± 0.31	1.23 ± 0.26	< 0.01*
MIS (Left)	0.94 ± 0.31	1.21 ± 0.27	< 0.01*

Legend: HGS = Hand Grip Strength; MIS = Maximum Isometric Strength; HGS (Right) = Hand Grip Strength - Right hand; HGS (Left) = Hand Grip; Strength - Left hand; MIS (Right) = Maximum Isometric Strength – Right knee extensor muscles; MIS (Left) = Maximum Isometric Strength - Left knee extensor muscles; ASD = Children with Autism Spectrum Disorder; Non-ASD = Children without Autism Spectrum Disorder; * significant difference between groups ($p < 0.01$). Note: self-elaboration.

Discussion

The main finding of the current study was the observation that children with ASD exhibit reduced muscular strength compared to children without ASD, thus confirming the initial hypothesis of this study. These results align with previous scientific evidence that indicated a negative impact of ASD on muscular strength, especially in children (Kern et al., 2013; Ludyga et al., 2021; Adin & Pancar, 2023).

In this context, some studies establish a relationship between HGS and the ability to perform daily activities such as opening doors, holding objects, tying shoelaces, among others (Alaniz et al., 2015; Ludyga et al., 2021). Therefore, it can be asserted that HGS plays a crucial role in an individual's ability to efficiently perform various every day and functional activities (Alaniz et al., 2015). Furthermore, HGS is one of the most commonly used variables for assessing muscular strength, particularly in children with ASD (Kern et al., 2013; Ludyga et al., 2021). Additionally, Kern et al. (2011) determined a significant negative correlation between HGS and the degree of ASD severity in children. However, it is worth noting that the reduced capacity for muscular strength production in this population could be influenced by other factors such as motor limitations (Shafer et al., 2021), balance (Hariri et al., 2022), and overall coordination (Umesawa et al., 2020).

However, it is important to emphasize that the scientific literature is scarce regarding the influence of ASD on muscular strength performance, as well as on the potential interventions that could be employed in the treatment of this disorder. Thus, the present study aimed to assess HGS in children with ASD and to measure the strength performance of other body segments, as measuring HGS alone does not clarify whether the capacity to produce force in other muscles or muscle groups might be affected (Kern et al., 2013).

In a similar study, Alaniz et al. (2015) analyzed HGS in children with and without ASD. The results showed that children with ASD have a reduced ability to produce muscular strength compared to children without ASD. Additionally, Kokaridas et al. (2018) elucidated that children with ASD exhibit lower muscular strength compared to children without ASD. Furthermore, in this study, HGS was measured with children standing and arms extended alongside their bodies. However, despite observing similar results to the findings of the current study, it is important to highlight the different protocols used in the present study and the study conducted by Kokaridas et al. (2018) for HGS measurement.

Furthermore, in a subsequent study, Coffey et al. (2021) examined the levels of physical fitness in children with and without ASD. They employed various tests to measure physical fitness, including the Hand Grip Strength (HGS) test and the standing long jump test. Additionally, HGS was measured with subjects standing, arms extended alongside the body, and elbows flexed at 90°. The authors found that ASD negatively influences the capacity to produce force in children aged four to thirteen. However, while the findings of Kokaridas et al. (2018) and Coffey et al. (2021) corroborate the results of the current study, it is relevant to note the different experimental protocols used in the present study and the studies conducted by Kokaridas et al. (2018) and Coffey et al. (2021) for HGS measurement. In line with the current study, Coffey et al. (2021) also assessed lower limb muscular strength, but they utilized a different manifestation of strength, namely muscular power. They employed a horizontal jump test to evaluate this type of strength, where children with ASD exhibited an average of 77.62 ± 36.95 centimeters and children without ASD had an average of 107.71 ± 26.02 centimeters, showing a significant difference ($p < 0.01$). Even though a different test and a distinct form of strength manifestation were used compared to the current study, the present study yielded similar results to those expressed in the studies conducted by Coffey et al. (2021). In other words, children with ASD demonstrate lower levels of strength in their lower limbs when compared to children without ASD.

Additionally, Ludyga et al. (2021) investigated the relationship between muscular strength and executive functions in children with and without ASD. Muscular strength was measured using the following tests: arm curl test, trunk curl test, and HGS test. However, it should be noted that experimental protocols were not detailed as the authors only mentioned following the Fitnessgram battery. As a result, it was observed that children with ASD exhibited lower muscular strength performance in all tests when compared to children without ASD. Nevertheless, while the results of the study conducted by Ludyga et al. (2021) confirm the findings of the present study, it's important to emphasize the distinct test designs used by Ludyga et al. (2021) and the present study for measuring muscular strength.

However, it is important to highlight that the present study has some significant methodological limitations, such as: a) using individuals from a specific age range; b) not distinguishing between individuals with and without comorbidities within the ASD group; c) employing only two tests to measure muscular strength; d) utilizing tests that measured only maximal isometric strength. Therefore, it is suggested that future research should involve individuals from different age ranges, differentiate between individuals with and without comorbidities, use a variety of tests to measure muscular strength, and assess other muscle actions such as concentric and eccentric actions.

Conclusions

Based on the findings of the present study, it is speculated that ASD negatively impacts the capacity to generate muscular strength in children. Furthermore, it is presumed that the reduced capacity for strength production in this population may be linked to restricted functional abilities and lower quality of life. Therefore, these conclusions can guide therapeutic interventions and support programs aimed at enhancing muscular strength, functionality, and well-being in children with ASD, particularly in the context of intervention.

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