



SPORMETRE

The Journal of Physical Education and Sport Sciences
Beden Eğitimi ve Spor Bilimleri Dergisi

DOI: 10.33689/spormetre.1607844
Research article



Geliş Tarihi (Received): 26.12.2024

Kabul Tarihi (Accepted): 23.06.2025

Online Yayın Tarihi (Published): 30.06.2025

COMPARISON OF UPPER EXTREMITY MUSCLE ARCHITECTURES OF INDIVIDUALS WITH AND WITHOUT INTELLECTUAL DISABILITY

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Abstract: Objective: The aim of this study is to compare and evaluate the upper extremity muscle architecture of individuals with and without intellectual disability by examining them using ultrasonography. The study aims to fill the gap in the literature regarding the muscle architecture of these individuals and to offer suggestions for increasing muscle health through physical activities. Methods: The physical activity level of 27 individuals with intellectual disabilities according to the International Physical Activity Questionnaire data was compared with 27 healthy individuals in a similar category. The images of the dominant side upper extremity muscles of both groups were examined by ultrasonography on different days and at the same time zone. In addition to ultrasound measurements, the individuals' hand grip strengths were determined. The images obtained with ultrasound were examined in the publicly available Image J program and the individuals' muscle thickness was determined. Results: It was determined that the hand region dorsal interosseous muscle, forearm ulna circumference muscles, upper arm anterior and posterior muscles and anterior deltoideus muscle thicknesses of individuals with intellectual disability were significantly lower than the individuals without intellectual disability. In addition, the grip strengths of these individuals were significantly lower than those of the control group. Conclusion: It is recommended that individuals with intellectual disabilities participate in programs that include resistance exercises, especially targeting the upper extremity muscle groups, in order to protect themselves from musculoskeletal problems such as sarcopenia and to increase their grip strength. It is thought that sports that support both physical and social participation, such as Boccia, may be beneficial for these individuals. In addition, this study provides unique guidance to trainers, physiotherapists and coaches, as it is one of the first studies in the literature to evaluate muscle architecture with ultrasonography in individuals with intellectual disabilities.

Anahtar Kelimeler: Intellectual disability, upper extremity muscle architecture, ultrasonography, muscle thickness, grip strength

ZİHİNSEL YETERSİZLİĞİ OLAN VE OLMAYAN BİREYLERİN ÜST EKSTREMİTE KAS MİMARİLERİNİN KARŞILAŞTIRILMASI

Öz: Amaç: Bu çalışmanın amacı, zihinsel yetersizliği olan ve olmayan bireylerin üst ekstremitte kas mimari yapılarının ultrasonografi yöntemiyle incelenerek karşılaştırılması ve değerlendirilmesidir. Çalışma, bu bireylerin kas mimarisine dair literatürdeki eksikliği doldurmayı ve fiziksel aktivitelerle kas sağlığını artırmaya yönelik öneriler sunmayı hedeflemektedir. Metod: Zihinsel yetersizliği olan 27 bireyin Uluslararası Fiziksel Aktivite Anketi verilerine göre fiziksel aktivite düzeyi, benzer kategoride yer alan 27 sağlıklı birey ile karşılaştırılmıştır. Her iki grubun dominant taraf üst ekstremitte kaslarının görüntüleri, farklı günlerde ve aynı saat diliminde ultrasonografi yöntemiyle incelenmiştir. Ultrason ölçümlerinin yanı sıra bireylerin el kavrama kuvvetleri tespit edilmiştir. Ultrasonla elde edilen görüntüler kamuya açık yazılımlı Image J programında incelenerek bireylerin kas kalınlıkları belirlenmiştir. Sonuç: Zihinsel yetersizliği olan bireylerin el bölgesi dorsal interosseöz kası, ön kol ulna çevresi kasları, üst kol anterior ve posterior kasları ile anterior deltoideus kas kalınlıklarının, zihinsel yetersizliği olmayan bireylere kıyasla anlamlı düzeyde düşük olduğu saptanmıştır. Ayrıca bu bireylerin kavrama kuvvetleri de kontrol grubuna göre belirgin şekilde daha düşüktür. Çözüm: Zihinsel yetersizliği olan bireylerin, sarkopeni gibi kas iskelet sistemi problemlerinden korunabilmeleri ve kavrama kuvvetlerini artırabilmeleri için özellikle üst ekstremitte kas gruplarını hedefleyen direnç egzersizlerini içeren programlara katılmaları önerilmektedir. Boccia gibi hem fiziksel hem de sosyal katılımı destekleyen sporların bu bireyler için faydalı olabileceği düşünülmektedir. Ayrıca, bu çalışma, zihinsel yetersizliği olan bireylerde ultrasonografi ile kas mimarisinin değerlendirilmesine yönelik literatürdeki ilk çalışmalardan biri olması nedeniyle eğitmenlere, fizyoterapistlere ve antrenörlere özgün bir rehberlik sunmaktadır.

Key Words: Zihinsel yetersizlik, üst ekstremitte kas mimarisi, ultrasonografi, kas kalınlığı, kavrama kuvveti



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INTRODUCTION

Intellectual disability (ID) is a condition defined by deficiencies in cognitive, fine and gross motor skills and delays in mental development during the development process of the individual. It usually occurs in childhood and causes permanent disorders in the individual's cognitive and adaptive functions. It is stated that approximately 1% of the world's population consists of individuals with ID (Bayındırlı, 2022). Individuals with intellectual disabilities face many important physical health problems as they get older. It was determined that these individuals are at higher risk of developing chronic diseases than healthy individuals, especially due to health conditions such as unhealthy nutrition, lack of physical activity and obesity (Liao et al., 2021).

Physical inactivity can lead to low muscle strength levels in association with some intrinsically dysfunctional muscle characteristics such as musculoskeletal problems, central nervous system deficiencies in the activation of motor units, hypotonia and atrophies (Borji et al., 2014). Additionally, premature aging at the physical level is a characteristic of individuals with intellectual disabilities and is associated with many diseases such as premature loss of muscle mass, impaired functional capacity and mobility (Bishop et al., 2013; Carmeli et al., 2012). Sarcopenia, one of these diseases, causes muscles to atrophy over time. This condition is associated with increased risk of death in individuals, with the loss of strength, a decrease in basal metabolic rate, physical dependence, falls and hospitalizations, and can negatively affect the ability to produce power (Carmeli et al., 2012; Duchowny et al., 2018; Zafeiridis et al., 2010). In addition, atrophies in the upper extremity muscles can cause these individuals to be unable to use their motor skills adequately (Kiram et al., 2023). This inability can cause fear of falling and functional inadequacy in daily life (holding a glass, toothbrush, pencil and fork) in individuals (Demirci N and Demirci PT). In addition, it was determined that the decrease in hand grip strength due to age is associated with an increased risk of functional impairment and adverse health conditions such as mortality and morbidity (Abe et al., 2015). In this context, structuring the physical activity and exercise levels of individuals with ID and increasing them in a planned manner is of great importance, especially for the health of the musculoskeletal system (Dasso, 2019).

Skeletal muscle is one of the most adaptable tissues in the human body and has the ability to adapt in response to changes in growth, growth hormones, metabolic activity, mechanical and loading demands, immobility, and neural drive (DiGirolamo et al., 2013; Gough and Shortland, 2012). During preschool childhood, when intellectual disability develops, typical motor development and functioning of skeletal muscles appear to be a necessary prerequisite for the development of motor functions (Forssberg, 1999). Furthermore, changes in muscle function are associated with delays or inaccessibility of motor pathways. There are a number of structural and operational features that can reduce the functional capacity of skeletal muscle, including changes in morphological and architectural features, physiological structure, and metabolic factors (Lieber, 2002; Stein and Wade, 2005).

In response to numerous interventions on the musculoskeletal system, it is very important to be able to measure changes in architectural and morphological parameters of skeletal muscle accurately and reliably. Imaging methods used to define muscle features include ultrasonography (USG). USG can detect values such as muscle belly length, muscle thickness, anatomical cross-sectional area, and fiber length and pennation angle as planar properties of the muscle (Williams et al., 2021). All of these parameters, when examined as a whole, constitute the definition of muscle architecture. In addition, understanding and modeling muscle

architecture and the arrangement and mechanics of muscles in the skeletal system will be a useful research topic for individuals who exercise in different contraction types (Holzbaur et al., 2005).

MRI scanning has been used in the literature to investigate muscle structure (Dağlı et al., 2023), but this method is expensive, time-consuming, and may be uncomfortable for participants with claustrophobia (Chopp et al., 2020). However, ultrasonography is applied as a more convenient method compared to other measurement methods in terms of cost and does not cause health problems by taking images with sound waves (Finnoff et al., 2016; Linek, 2017; Sikdar et al., 2014). The relationship between upper extremity muscle thickness and strength has been determined in the literature. However, no study has been found on the muscle architecture structures of individuals with ID (Abe et al., 2014). Therefore, in the current study, the USG method was preferred to evaluate the muscle architecture parameters of individuals with ID. In addition, in order to contribute to the literature, the main goal of this study is to compare the upper extremity muscle architecture of individuals with and without intellectual disability who have similar physical activity levels. In this context, the current study aims to guide physiotherapists and coaches who prepare physical activity and exercise programs for individuals with ID.

METHODS

Research Design

In the current study, a comparative cross-sectional research model, which is among the quantitative research methods, was preferred.

All participants were informed not to use coffee, alcohol and medication before the test days and to avoid strenuous physical activities. Before the test, the height and weight of all individuals were measured, and the dominant upper extremity regions were assumed to be the regions where they use pencils or forks. The measurements were carried out between 12:00 and 14:00 in order to minimize biological variations and were completed in a total of three days.

Participants

Twenty-seven individuals, twenty female and seven male, diagnosed with intellectual disability ($n=27$; mean age 36.4 ± 10.6 years; mean height 165 ± 8.3 cm; mean body weight 64.2 ± 7 kg) and twenty female and seven male healthy individuals ($n=27$; mean age 34.4 ± 11.7 years; mean height 165.9 ± 8.9 cm; mean body weight 67.1 ± 24.5 kg) were included in this study. Participants' descriptive statistics are presented in Table 1. In order to take measurements from individuals with intellectual disability, the necessary permissions were obtained from the Akran Akademi Private Education Institution in Bayburt province. The study was conducted in accordance with the World Medical Association Declaration of Helsinki and was approved by the Bayburt University Ethics Committee on 17th October 2024. The purpose, protocol, risks, and benefits of the study were explained to the participants in detail, and a voluntary consent form was signed.

Table 1. Descriptive Data of Participants

| Group | Gender (F/M) | n | Age (mean \pm SD) | Height (mean \pm SD) (cm) | Body Weight (mean \pm SD) (kg) |
|------------------|--------------|----|---------------------|-----------------------------|----------------------------------|
| Group with ID | 20 / 7 | 27 | 36.4 \pm 10.6 | 165.0 \pm 8.3 | 64.2 \pm 7.0 |
| Group without ID | 20 / 7 | 27 | 34.4 \pm 11.7 | 165.9 \pm 8.9 | 67.1 \pm 24.5 |

Note: Data are presented as mean \pm standard deviation (SD). ID = Intellectual Disability.

Inclusion Criteria

The health reports of the individuals with ID participating in the study were examined, and participants who had no history of upper extremity injury within 6 months, no current disability related to the hand, wrist, forearm, arm and shoulder, no inflammation, pain, edema or functional disorder in these regions and no disability or limitation related to the upper extremity were included in the study. In addition, individuals without ID participating in the study were required to be free of significant chronic diseases such as angina, diabetes, arthritis, stroke, neuromuscular disorders and cancer, with regard to their own statements based on annual health examinations (Abe et al., 2014). Participants did not use any medications known to affect the muscles neuromuscularly, such as angiotensin II receptor blockers, statins, steroids or antidiabetic drugs. Moreover, individuals without ID but with physical activity levels similar to those with ID were included in the study (Craig et al., 2003).

Ultrasonographic Assessment

Muscle architecture measurements were performed with a SonoHealth brand (dual) sector + linear probe B-mode ultrasound device. While taking ultrasound images, measurements were made from the point marked at the 55% distal distance between the palmar digital fold and the wrist flexion fold indicated in Figure 1 (A) for upper extremity hand muscle architecture measurements. The ultrasound images of the forearm muscles shown in Figure 1 (B) were taken from a point marked at the 30% proximal distance between the styloid process of the ulna and the radial head (Schmalzl et al., 2022). For measurements related to anterior deltoideus muscle architecture, measurements were taken from the marked area 5 cm medial to the bicipital groove of the humerus (the most bulging area of the muscle) (Audenaert et al., 2009; Schmalzl et al., 2022).

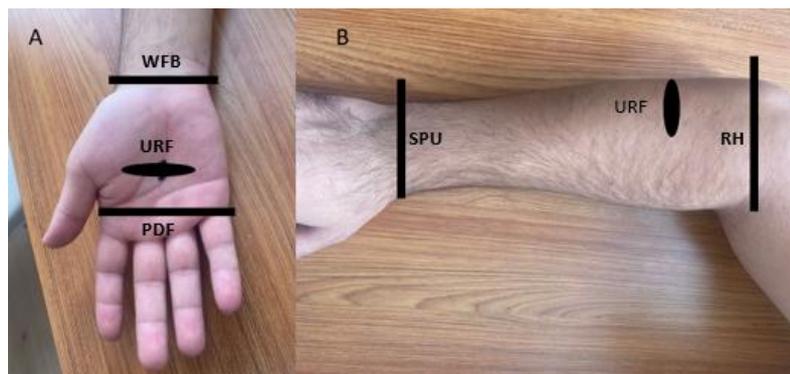


Figure 1: Ultrasound measurement regions on the hand (A) and forearm (B). WFB: Wrist flexion bend, PDF: Palmar digital fold, URF: Ultrasound reference point, SPU: Styloid process ulna, RH: Radius head

The measurements of the anterior and posterior upper arm muscle architecture were taken from the point marked 60% distal between the lateral epicondyle of the humerus and the acromial process of the shoulder, as indicated in Figure 2 (C) (Abe et al., 2014). For measurements related to the anterior deltoideus muscle architecture, measurements were taken from the point marked 5 cm medial to the bicipital groove of the humerus (the most bulging area of the muscle), as indicated in Figure 2 (D) (Audenaert et al., 2009; Schmalzl et al., 2022).

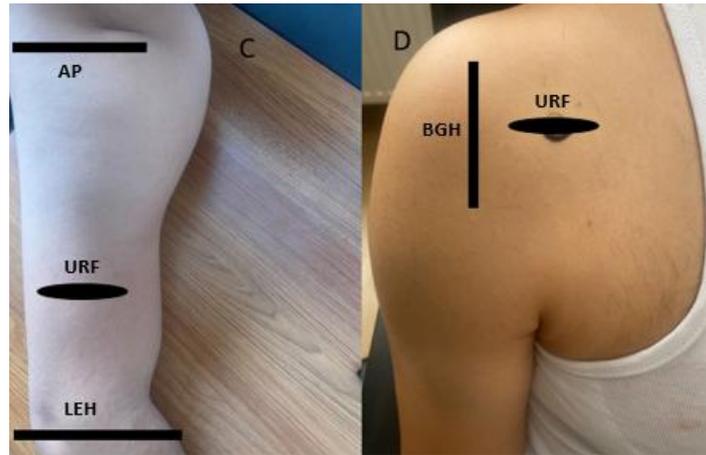


Figure 2: Ultrasound measurement regions of the upper arm (C) and anterior deltoideus (D). AP: Acromial process, LEH: Lateral epicondyle humerus, URF: Ultrasound reference point, BGH: Bicipital groove humerus

After measuring the limb length using anatomical landmarks, all measurement regions were marked with a marking pen. During the measurements, the participants kept their elbows in a relaxed position. The points where the USG images would be taken were covered with water-based transmission gel to provide acoustic contact and to obtain a clear image by reducing the pressure of the scanning head. The scanning head was placed on the skin surface of the measurement region by an expert with minimal pressure, and cross-sections of each muscle were imaged. Three images were taken from each region, and the average values of each region were used in the data analysis. The subcutaneous fat tissue-muscle interface and the muscle-bone interface were determined in the ultrasound image, and the distance between the two interfaces was accepted as the muscle thickness for the limb muscles. The images were transferred to the publicly available software (ImageJ, v.1.46; National Institutes of Health, Bethesda, MD, USA) to measure the length, and the blind method was used in the length measurements taken from the images.

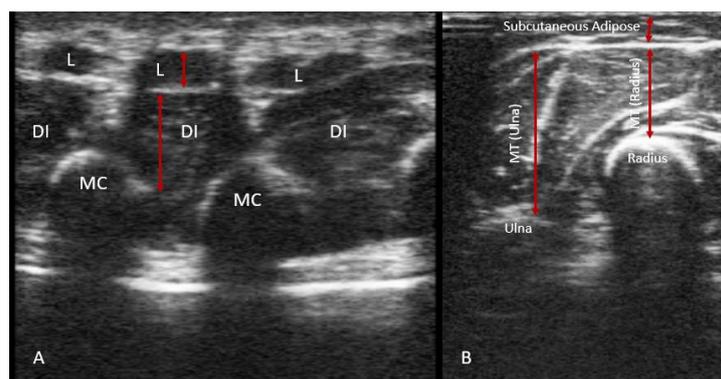


Figure 3: Analysis of muscle thickness in the hand (A) and forearm (B) regions. L: Lumbrical, DI: Dorsal Interosseous, MC: Metacarpal, MT: Muscle Thickness

Hand Grip Strength Measurement

The dominant hand grip strength measurement is one of the most common measurement protocols. The grip strength measurements were taken three times with the Jamar Hydraulic Hand Dynamometer while the participant was sitting in a back-supported chair, the arm was abducted, the elbow was in 90° flexion, the forearm was in a neutral position and the wrist was in 0-30° extension. The highest value obtained was recorded (Wen et al., 2020).

Reliability of Ultrasound Measurements

To test the intraobserver reliability of ultrasound measurements, images taken from individuals were re-evaluated by the same investigator one week later. The numerical values of previous images were blinded to avoid bias. Intraclass correlation coefficient (ICC) was calculated using a two-way mixed model to assess reliability between two measurements. ICC values below 0.69, between 0.70-0.79, 0.80-0.89, and 0.90-0.99 indicate poor reliability, moderate, good, and high reliability, respectively (Taylor, 1990).

Table 2. Reliability Values of Ultrasound Measurements

| Parameters | 1 st Test for Group with ID (Mean ± SD)) | 1 st Test for Non-ID Group (Mean ± SD)) | 2 nd Test for Group with ID (Mean ± SD)) | 2 nd Test for Non-ID Group (Mean ± SD)) | ICC Value (Group 1) | ICC Value (Group 2) |
|---------------------------------|---|--|---|--|---------------------|---------------------|
| L-MT | 0.43±0.09 | 0.45±0.10 | 0.42±0.09 | 0.44±0.1 | 0.96 | 0.92 |
| DI-MT | 0.86±0.17 | 0.98±0.15 | 0.85±0.15 | 0.99±0.16 | 0.94 | 0.64 |
| Forearm (Radius) MT | 1.63±0.52 | 1.75±0.44 | 1.6±0.53 | 1.74±0.43 | 0.97 | 0.97 |
| Forearm (Ulna) MT | 3.18±0.59 | 3.53±0.52 | 3.2±0.56 | 3.53±0.52 | 0.97 | 0.99 |
| Upper Arm (Anterior) MT | 2.16±0.13 | 2.39±0.29 | 2.19±0.25 | 2.38±0.3 | 0.93 | 0.91 |
| Upper Arm (Posterior) MT | 2.26±0.14 | 2.55±0.40 | 2.25±0.14 | 2.56±0.40 | 0.99 | 0.96 |
| Anterior Deltoideus MT | 0.89±0.19 | 1.19±0.23 | 0.86±0.17 | 1.2±0.22 | 0.99 | 0.99 |

MT: Muscle Thickness, **L:** Lumbrical, **DI:** Dorsal Interosseous, **SD:** Standard deviation, **ICC:** Intraclass Correlation Coefficient. Muscle thicknesses are listed in cm.

Table 2 presents the mean ± SD values and ICC scores between measurements. The ICC scores measured between the first and seventh days were as follows: 0.96 cm for lumbrical muscle thickness in the hand region, 0.94 cm for dorsal interosseous muscle thickness, 0.97 cm for radius circumference muscle thickness in the forearm, 0.97 cm for ulna circumference muscle thickness, 0.93 cm for upper arm anterior muscle thickness, 0.93 cm for upper arm posterior muscle thickness, and 0.99 cm for anterior deltoideus muscle thickness (Şekir et al., 2022).

Statistical Analysis

Statistical analysis was performed using SPSS v.26.0 (IBM SPSS Statistics) software. Mean±standard deviations were used to describe all variables. The significance level was accepted as $p < 0.05$. Shapiro-Wilk test was used to evaluate the normality distribution of the data. Normally distributed data were analyzed with Independent Sample t test and non-normally distributed data were analyzed with Mann-Whitney U test.

RESULTS

The findings of the study are presented in tables.

Table 3. Comparison of Physical Activity Levels Between Individuals with Intellectual Disability and Healthy Controls

| Group | Mean \pm SD | t value | p value (2-tailed) |
|------------------|--------------------|---------|--------------------|
| Group with ID | 566.93 \pm 76.76 | -0.461 | 0.647 |
| Group without ID | 577.56 \pm 92.14 | | |

p<0.05* Note: Values are presented as mean \pm standard deviation (SD). Independent samples t-test was used to compare groups. ID = Intellectual Disability.

As shown in Table 3, there was no statistically significant difference in physical activity levels between individuals with intellectual disability (566.93 \pm 76.76) and healthy controls (577.56 \pm 92.14) ($t = -0.461$, $p = 0.647$). This indicates that the average physical activity scores of both groups were similar.

Table 4. Data regarding the Independent Simple T test analysis of the differences between muscle thickness and grip strength of individuals with and without ID.

| Parameters | Group with ID (Mean \pm SD) | Group without ID (Mean \pm SD)) | Test Statistics (t/U) | p | Effect Size |
|--------------------------------|----------------------------------|--------------------------------------|-----------------------------|----------------|-------------|
| L-MT | 0.43 \pm 0.09 | 0.45 \pm 0.10 | -0.548 | .586 | -0.15 |
| DI-MT | 0.86 \pm 0.17 | 0.98 \pm 0.15 | -2.668 | .010* | -0.7 |
| Forearm (Radius) MT | 1.63 \pm 0.52 | 1.75 \pm 0.44 | -0.921 | .361 | 0.25 |
| Forearm (Ulna) MT | 3.18 \pm 0.59 | 3.53 \pm 0.52 | -2.297 | .026* | -0.63 |
| Upper Arm (Anterior) MT | 2.16 \pm 0.13 | 2.39 \pm 0.29 | -3.717 | 0.000** | -1 |
| Upper Arm (Posterior) MT | 2.26 \pm 0.14 | 2.55 \pm 0.40 | -3.538 | 0.001* | -0.9 |
| Anterior Deltoideus MT | 0.89 \pm 0.19 | 1.19 \pm 0.23 | -5.244 | .000** | -1.5 |
| Handgrip Strength | 18.14 \pm 11.09 | 33.04 \pm 8.88 | -5.451 | 0.000** | -0.14 |

p<0.05* MT: Muscle Thickness, L: Lumbrical, DI: Dorsal Interosseous, SD: Standard deviation. Muscle thicknesses are listed in cm.

Table 4 presents the thickness and grip strength of the hand (lumbrical-dorsal interosseous), forearm (MT radius, MT ulna), upper arm (anterior, posterior) and anterior deltoideus muscles in individuals with and without ID. In the hand region, lumbrical muscle thickness was not found to be statistically different between the two groups ($p > 0.05$). However, dorsal interosseous muscle thickness was found to be significantly greater in individuals without ID than in individuals with ID ($p < 0.05$).

When forearm muscle thicknesses were examined, MT radius did not show a statistically significant difference between the two groups ($p > 0.05$). However, MT ulna was found to be significantly larger in individuals without ID than in individuals with ID ($p < 0.05$). When upper arm muscle thicknesses were examined, it was found that the muscle thicknesses of the anterior and posterior regions of the upper arms of individuals without ID were statistically larger than in individuals with ID ($p < 0.05$). Similarly, the anterior deltoideus muscle was found to be larger

in individuals without ID ($p < 0.05$). In addition, grip strengths were found to be significantly higher in individuals without ID than the individuals with ID ($p < 0.05$).

DISCUSSION

This study aimed to compare the upper extremity muscle architectural structures of individuals with and without ID at similar physical activity levels. For this purpose, it was determined that the hand (dorsal interosseous), forearm (flexor muscles) and anterior shoulder (anterior deltoideus) muscle thicknesses and grip strength of individuals with ID were smaller than those of individuals without ID.

The physical activity levels of individuals with intellectual disability were found not to differ significantly compared to healthy individuals. The average physical activity scores of both groups were similar, indicating the potential for individuals with intellectual disability to be included in appropriate physical activity programs aimed at improving their quality of life and maintaining their health. Although the literature generally reports that individuals with intellectual disability have lower physical activity levels (Cho et al., 2021; Dairo et al., 2016), some studies emphasize that with appropriate interventions, their physical activity levels can be increased, thereby improving cardiovascular health, muscle strength, and overall functional capacity (Güvendi and İlhan, 2017).

Grip strength can be used to predict the prognosis of many diseases such as chronic cardiovascular diseases (Rantanen et al., 2003), because a decrease in grip strength can be proportional to skeletal muscle loss, and hand grip strength can provide clinically useful information to evaluate whole-body skeletal muscle mass in some populations (Evans et al., 2008). Grip strength is also used as an assessment method to diagnose sarcopenia in individuals at advanced ages (Morimoto et al., 2017). Grip strength is largely related to the thickness of the hand muscles and forearm muscles (Abe et al., 2015; Abe et al., 2016). The hand muscles consist of the thenar, hypothenar, and middle carpal muscles. The two main flexor muscles, the dorsal interosseous and lumbrical muscles, are located between the metacarpals (Rizzolo and Drake, 2008). In this context, it can be said that the thickness of the dorsal interosseous-lumbrical muscles and forearm muscles in the hand region, which are related to grip strength, are related to musculoskeletal diseases such as sarcopenia.

In the present study, the thickness of the lumbrical and dorsal interosseous muscles of individuals with ID was determined to be 0.43 cm and 0.86 cm, respectively, while that of individuals without ID was determined to be 0.45 cm and 0.98 cm. In the study conducted by Abe et al. (2015), the thickness of the lumbrical and dorsal interosseous muscles of 43 young (24 years) men was determined to be 0.43 cm and 1.10 cm, respectively, and of 43 young (23 years) women was determined to be 0.33 cm and 0.87 cm. In this context, similar data were obtained with other researchers who measured the hand region in the present study (Abe et al., 2015; Aoyama and Kohno, 2020; Rizzolo and Drake, 2008).

In the proximal part of the forearm, the flexor digitorum profundus and flexor digitorum superficialis muscles, which are the main flexor muscles of the fingers, are located close to the ulna, while the pronator teres and brachioradialis muscles are located close to the radius. In the present study, it was determined that the muscle thicknesses in the radius and ulna regions of individuals with ID were 1.63 cm and 3.18 cm, respectively, while those of individuals without ID were 1.75 cm and 3.53 cm. In the study conducted by Abe et al. (2014), it was reported that the radius and ulna muscle thicknesses of 32 old men were 1.92 cm and 3.78 cm, respectively,

while those of 21 old women were 1.55 cm and 3.13 cm. These findings are largely consistent with the results of the present study. However, Morimoto et al. (2017) reported the muscle thicknesses of 30 healthy young men (22 years) in the radius and ulna regions as 2.23 cm and 4.16 cm, respectively. These findings are inconsistent with the results obtained in the current study. This difference is thought to be related to the fact that 74% of the participants in the current study were women. The literature supports that women generally have lower muscle thickness than men (Morimoto et al., 2017). In addition, method differences and changes in age range may be one of the reasons for these differences.

In the present study, MT radii of individuals with ID were found to be similar to those without ID, while MT ulna muscle thickness of individuals with ID was found to be smaller. This finding supports previous studies (Abe et al., 2014; Abe et al., 2015; Morimoto et al., 2017; Trinidad et al., 2020) showing that weakness of flexor digitorum profundus and flexor digitorum superficialis muscles, which provide flexion function for the middle phalanx of the fingers in individuals with ID, is associated with their low grip strength. In this context, adding resistance exercises for these muscle groups while planning exercises for individuals with ID may help increase muscle strength and improve functional capacity.

In this study, the upper arm muscles were evaluated in two main groups: the biceps brachii and brachialis muscles, which play a role in arm flexion, and the triceps brachii muscle, which plays a role in arm extension. In the current study, the upper arm front and back muscle thicknesses of individuals with ID were found to be 2.16 cm and 2.26 cm, respectively, while these values were found to be 2.39 cm and 2.55 cm in individuals without ID. In a study conducted by Abe, T., Loenneke, J. P., Thiebaud et al. (2014), the upper arm front and back muscle thicknesses of 83 adult women were measured as 2.24 cm and 2.35 cm, respectively. These findings are similar to the values in the current study. However, the muscle thicknesses of individuals without ID were found to be higher than the findings of Abe et al. (2014). It is thought that the main reason for this difference may be due to the different gender distribution of the participants in the current study, because male participants increased the average in muscle thickness.

In the current study, it was determined that the upper arm front and back muscle thicknesses of individuals with ID were lower than those of individuals without ID. Zaccagni et al. (2020) stated in their study that upper arm muscle thickness significantly affected grip strength. These findings indicate that the weak upper arm muscle thickness of individuals with ID may cause low grip strength. The results obtained are consistent with the situations where individuals with ID experience more dependence on self-care, housework and leisure activities in daily life and therefore their muscle strength is less developed (Kurtoğlu et al., 2022; Zaccagni et al., 2020). In this context, the importance of exercise programs aimed at strengthening the upper arm muscle groups of individuals with ID should be emphasized.

In the present study, it was determined that the anterior deltoideus muscle thickness of individuals with ID was lower than that of individuals without ID (0.89 cm and 1.19 cm). The anterior deltoideus muscle plays an important role in daily life activities by acting in arm flexion, internal rotation and horizontal adduction. In particular, it has functions such as pushing and throwing objects or providing support for the arm during falling to the ground. Weakening of this muscle may negatively affect shoulder joint stability and increase the risk of injury (Stokey et al., 2024). Therefore, it is recommended that trainers, physiotherapists and families working with individuals with ID include resistance exercises (e.g. arm flexion exercises with theraband) in their exercise plans to strengthen their anterior deltoideus muscle.

Limitations of the Study

In the present study, the evaluation of muscle architectural parameters was limited to the upper extremity. In addition, ultrasound imaging analyses were limited to muscle thickness measurements only. These limitations narrowed the scope of the study but allowed for an in-depth examination of the findings in a specific area. In addition, the majority of participants were female (74%), which may have limited the full assessment of gender-related differences in muscle thickness and strength data.

CONCLUSION

This study revealed that the thickness of the dorsal interosseous muscle of the hand region, the muscles around the radius of the forearm (flexor digitorum profundus, flexor digitorum superficialis), the upper arm muscles (biceps brachii, brachialis, triceps brachii) and the anterior deltoideus muscles of individuals with ID were lower than the individuals without ID, and that the grip strengths of individuals with ID were lower than those of individuals without ID. These findings emphasize the importance of specific interventions for resistance exercises in order to prevent musculoskeletal problems such as sarcopenia in individuals with ID and to facilitate their daily life activities. In addition, this study contributes to the literature as the first study to evaluate the upper extremity muscles in individuals with ID using ultrasonography. In this context, it is thought that the findings obtained will guide trainers, physiotherapists and coaches in developing more effective physical activity and rehabilitation programs. In this context, the importance of the current study is presented as follows:

- In order to increase the thickness of the dorsal interosseous and MT ulna muscles, it is recommended that physiotherapists and sports scientists, who plan exercises for individuals with ID, add resistance exercises that include finger adduction and flexion, and wrist flexion movements to their programs. In this way, an increase in the fine motor skills and grip strength of individuals with ID can be achieved.
- In particular, low-impact sports that support muscle strength, such as boccia, are recommended as an effective tool for individuals with ID to develop their physical skills. In addition, it is of great importance for those working with individuals with ID to prepare exercise plans that include resistance exercises targeting the upper arm muscles and anterior deltoideus muscle.
- In future studies, male and female participants should be analyzed separately through subgroup analyses to better evaluate gender-related differences.

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