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Comparison of Lower and Upper Extremity Strength of Individuals with Down Syndrome in Terms of Age Groups and Gender

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Abstract

The purpose of this study was to compare lower and upper extremity strength of individuals with Down syndrome in terms of age and gender. Nineteen females (52.8%) and 17 males (47.2%) individuals with Down syndrome (Trisomy 21 type) who continue special education and rehabilitation centers participated in the study. The average age of participants was 21.25±6.25 years, average height: 152.18±8.01cm, body weight average: 65.60±18.28kg. There was no statistically significant difference between lower and upper extremity results of Down's syndrome patients ($p < 0.05$). In terms of gender, (Female: 15.8±5.6, male: 11.9 ± 4.8, $p=0.03$) it were found to be statistically better than boys in terms of horizontal jump (female: 71.7±20.5, male: 55.12±19.7, $p=0.02$) and vertical jump. As a result, lower and upper extremity strength in different age groups of individuals was found to be similar. However, it can be said that girls with Down syndrome have better explosive strength than men.

1. Introduction

Down syndrome (DS) is a congenital autosomal anomaly characterized by growth and mental retardation. It is indicated that DS children have hypotonic muscle structures and low muscle strength (Pitetti et al., 2013; Mendonca, Pereira, & Fernhall, 2010; Marchala et al., 2016). It is emphasized that the hypotonic structure also lowers the quality of life of DS children and can negatively affect the self-care and academic skills (Agiovlasitis, Mccubbin, Yun, Mpitsos & Pavol, 2009; Carmeli, Ayalon, Barchad, Sheklow & Reznick, 2002; Pitetti et al. 1992). It has also been reported that muscle strength of DS individuals is of great importance for the survival of later ages, for the preservation of dynamic balance skills, for their functional independence and for increasing their quality of life (Carmeli, Kessel, Coleman, & Ayalon, 2002).

Muscle strength and exercise capacity are reported to be important factors for the daily living skills of DS individuals (eating, drinking, dressing, standing,

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walking, etc.) (Mendonca et al., 2010; Guerra, Bofill, Cartes & Fernhall, 2006). Thus, when analyzed literature for improving muscle strength; many exercise programs are available for individuals with Down's syndrome (Cowley et al., 2011; Kolber, Beekhuizen, Cheng & Hellman, 2010; Phadke, Camargo & Ludewig, 2009; Rimmer, Heller, Wang & Valerio, 2004; Weber & French, 1988; Shields & Taylor, 2010; Shields, Taylor & Dodd, 2008; Tsimaras & Fotiadou, 2004; Mendonca et al., 2011). However, in the literature studies, it has been found that there are a limited number of studies on the comparison of lower and upper extremity muscle strength with age of the individuals with Down syndrome.

There are also different opinions in these studies (Cabeza-Ruiz et al., 2008; Van Gameren-Oosterom et al., 2011; Hartman et al., 2015; Marchala et al., 2016). For this reason, age differences or gender parameters were considered to have an effect on muscle strength. In this context; this study was conducted to compare lower and upper extremity forces according to age and gender of individuals with Down syndrome.

2. Material and methods

Aim and hypothesis

The main purpose of this study was to compare lower and upper extremity strength of individuals with Down syndrome in terms of age and gender. There are two main hypotheses in this study. First hypothesis is “there are statistical differences between age groups in terms of lower and upper Extremity Strength”. Second hypothesis is “there are statistical differences between gender groups in terms of lower and upper Extremity Strength”.

Participants

A total of 36 individuals with DS (21 types of Trisomy 21) (who have normally hearing, cardiovascular, physical and visual functions and not regular sports), 19 girls (52.8%) and 17 boys (47.2%) who continued to Special Education and Rehabilitation Centers, participated voluntarily. Participants were divided into 3 groups in terms of age groups. Group I: 13-17 years (n=12), II. Group 18-24 years (n=14), III. Group: 25-34 years (n=10). The average age of participants was 21.25±6.25 years, average height: 152.18±8.01cm, body weight average: 65.60±18.28kg, special education attendance status; the mean day (weekly) average was 3± 0.63 days, and the average was 1.00 hours per day.

Measure Equipments

In the study, Takei brand hand dynamometer (right-left hand) and isometric push-up (tense arm) methods were used to measure the upper extremity strength of the individuals. For lower extremity force; horizontal-vertical jump, wall squat test, Takei brand leg dynamometer tests were performed. In the analysis of the data, SPSS 21 package program was used.

Figure 1. *Hand (left-right) grip test*

Figure 2. *Isometric push-up test*

Figure 3. *Vertical jump Test*

Figure 4. *Wall squat test*

Measurements

• *Hand Dynamometer Test (Takei Brand)* – (Onyewadume, 2006; Josária et.al., 2012; Amaral, Mancini & Novo Júnior, 2012): The instrument was adjusted to the hand of the individual and measured in right and left hand by bringing the person into standing and arm stretched 45^0 abduction from the body.

• *Leg Dynamometer test (Takei Brand)*: Once the test is shown on the dynamometer by researcher, and then the individual is removed on the

dynamometer. In the upright position, the dynamometer is set on the individual knee level of the chain. The individual who is ready similar to the basketball in the stance position is asked to pull the dynamometer chain up from the upper legs while taking his back while standing up and gazing across the eyes. The reading was recorded in kg.

- *Vertical jump Test:* A Takei brand jump meter was used. The distance that the person jumped and jumped up with all the power, without stepping on the sensitive ground with time and distance scale, was determined on the device in terms of centimeters.
- *Horizontal jump test* (Wang & Ju, 2002): The individuals performed the best horizontal jump from where the double leg is behind the marked line. The distance between the marked line and the nearest track made by the jumper was measured in meters.
- *Wall squat test* (Multani, Singh & Singh, 2013): The individual is expected to wait in the leg shoulder width and half squat position, with the back facing the wall, the arms parallel to the side and in front of the body. The stopwatch is started when the position is not received. When the position is broken, the stopwatch is stopped and the value is recorded.
- *Isometric Push-up Test*: It is also included in the Brockport Physical Fitness Test Battery (Winnick & Short, 1999). The individual was brought to the push-up position (stretched arm) on the cushion. The stopwatch is activated when the position is cleared. When the position is disturbed, the stopwatch is turned off and the value is recorded (Karakaya, Aki & Ergun, 2009). In addition, Ince and Delikçi's (2016) work on DS individuals; showed a significant correlation with the modified influential isometric push up (hold position) test and hand influx dynamometer test results.

Statistical Analyzes

All measurements were taken two times and the best value was recorded. Statistical analyzes were performed in the SPSS 21.0 packet program (frequency, mean, standard deviation).

The Shapiro-Wilk test was performed to test whether the data showed a normal distribution because the sample number was less than 50. The result is; our data show normal distribution as horizontal ($p = 0.12$) and vertical jump ($p = 0.91$) values increase by $p > 0.05$. For this reason parametric tests have been applied. One-way analysis of variance (ANOVA) was used to compare the t-test in two comparisons and the two-way averages. However, other isometric push-ups ($p=0.005$), wall squat ($p = 0.01$), right hand ($p = 0.001$), left hand ($p = 0.002$), our data do not show normal distribution. Nonparametric tests were used. Mann-Whitney U in binary comparisons; Kruskal Wallis test was applied.

3. Results and Discussions

The demographic characteristics of individuals with DS participated to study are given in Table 1.

Table 1. *Demographic characteristics of individuals with DS participating in the study*

Features	n	min	max	mean	S.d.±
Age (years)	36	13,00	34,00	21,25	6,25
Boy height (cm)		137,00	168,00	152,18	8,01
VA Body Weight		35,90	113,50	65,60	18,3
Special education frequency (Days per week)		2,00	4,00	3,00	0.63
Special education duration (Daily Hours)		1,00	1,00	1,00	0,00

Table 2. *Mann-Whitney U Test results of ds individuals' lower and up extremity force tests in terms of gender*

Tests	Gender	n	mean rank	z	p
Isometric push-up	Female	19	17,42	-0,650	0,516
	Male	17	19,71		
Wall squat	Female	19	21,58	-1,854	0,064
	Male	17	15,06		
Leg dynamometer	Female	19	18,82	-0,190	0,849
	Male	17	18,15		
Hand grip (right)	Female	19	17,74	-0,460	0,645
	Male	17	19,35		
Hand grip (left)	Female	19	18,76	-0,159	0,874
	Male	17	18,21		

Mean age of the participating DS individuals was 21.25 ± 6.25, mean height was 152.18 ± 8.01, body weight average was 65.60 ± 18.3, the average number of days of special education was 3±0,63 days per week, 1±0,00, respectively. The result of Mann-Whitney U test in terms of gender related to lower and upper extremity strength tests of participants is given Table 2.

There was no significant difference in DS subjects compared to lower and upper extremity strength test results (upper extremity strength test: isometric push-up, wall squat, leg dynamometer and lower extremity test: hand grip (right-left) genders. Independent t-test results for DS individuals in terms of gender of lower extremity jump tests Table 3.

Table 3. *Independent t-test results of DS extreme jump tests of individuals by gender*

Tests	Gender	n	mean	S.d.	p
Horizontal jump	female	19	71,71	20,50	**0,02***
	male	17	55,12	19,71	
Vertical Jump	female	19	15,79	5,57	**0,03***
	male	17	11,88	4,79	

*p<0.05

A statistically significant difference was seen when the males and females were compared with DS lower extremity jump tests (horizontal-vertical jump). It

was found that the mean values of the horizontal (71.71 ± 20.50) and vertical (15.79 ± 5.57) jump were higher than that of boys (horizontal: (55.12 ± 19.71) and vertical: (11.88 ± 4.79) (Horizontal jump p =, 02, horizontal jump p = .03).

The results of ANOVA test for age groups of lower extremity jump tests of DS individuals are shown in Table 4.

Table 4. *ANOVA test results of DS jump tests of individuals in terms of age groups*

Tests	Age groups	n	mean	S.d.	F	p
Horizontal jump	13-17	12	62,21	16,33	0,233	0,79
	18-24	14	67,00	23,02		
	25-34	10	61,50	26,26		
	Total	36	63,88	21,55		
Vertical jump	13-17	12	14,42	6,57	0,786	0,46
	18-24	14	14,85	4,87		
	25-34	10	12,10	5,09		
	Total	36	13,94	5,51		

There was no significant difference between age groups of DS individuals in lower extremity jump force tests (horizontal-vertical jump) (p> 0.05). Kruskal Wallis test results of lower and upper extremity strength tests of DS in terms of age groups individuals are given in Table 5.

Table 5. *Kruskal Wallis Test results for age groups of lower and up extremity force tests of ds individuals*

Tests	Age groups	n	mean	S.d.	Mean Rank	Chi-Square	P
Isometric push-up	13-17	12	27.87	8.05	17,13	0,38	0,83
	18-24	14	31.18	14.83	18,71		
	25-34	10	29.82	9.39	19,85		
	Total	36	29.70	11.26			
Wall squat	13-17	12	27.18	17.93	16,67	0,82	0,67
	18-24	14	29.38	11.46	20,36		
	25-34	10	26.89	11.54	18,10		
	Total	36	27.95	13.62			
Hand grip (right)	13-17	12	17.54	8.56	16,79	1,74	0,42
	18-24	14	19.86	6.64	21,39		
	25-34	10	16.55	5.01	16,50		
	Total	36	18.17	6.92			
Hand grip (left)	13-17	12	17.17	6.70	17,38	0,21	0,90
	18-24	14	19.79	9.19	19,07		
	25-34	10	17.55	4.44	19,05		
	Total	36	18.29	7.21			
Leg dynamometer	13-17	12	25.42	13.49	13,92	3,65	0,16
	18-24	14	38.79	17.78	21,68		
	25-34	10	35.85	20.13	19,55		
	Total	36	33.51	17.72			

When DS individuals were assessed by age (upper extremity strength tests) despite the fact that the mean values of DS individuals between the ages of 18-24

were better than the other groups, no statistically significant difference was found between them ($p > 0.05$).

When the analyses of literature, the physical fitness of DS individuals; cardiovascular fitness, low aerobic capacity, low heart rate and low muscle strength have been reported to be associated with higher obesity tendencies (Pitetti, Baynard & Agiovlasitis, 2013, Mendonca et al., 2010). There is also a positive relationship between muscle strength and aerobic capacity (Cowley et al., 2011). Also, DS emphasizes that individuals are important because of the development of lower body strength, aerobic capacity, and physical work capacity (Mendonca et al., 2010).

In our study, DS individuals who did not attend regular sport activities had lower extremity strength tests; Wall squat and leg dynamometer test and upper extremity strength test; Isometric push-up, right-left hand grip test results and genders are compared; there was no significant difference between them ($p > 0.05$). DS individuals have been reported to have a strong association between muscle hypotonia and muscle strength (Priosti, Blascovi-Assis, Cymrot, Vianna & Caromano, 2013). Also, when DS handicapping skills of individuals and normal development individuals are compared, DS individuals were found to have lower hand grips. It is emphasized that this may be due to the strong association between muscle hypotonia and strength deficits in DS individuals (Sharav & Bowman, 1992; Pitetti, Climstein, Mays & Barrett, 1992). Unlike the results of our study, Cabeza-Ruiz et al. Studies of adult DS individuals (14 male-8 female, 26.77 ± 6.07 years) on hand grip strength; Gender differences. Male DS indicated that the hand grips of the individuals were better than the DS DS individuals. However, they have emphasized that girls are able to reach maximal isometric power faster than boys (Cabeza-Ruiz et al., 2008).

In our study, a statistically significant difference was observed when DS subjects compared gender with lower-extremity jump force tests (horizontal-vertical jump). It was found that the average values of the jump (71.71 ± 20.50 cm) and vertical (15.79 ± 5.57 cm) jumps were higher for girls than for boys (horizontal: (55,12 ± 19.71) and vertical (11,88 ± 4.79) (Wang & Ju, 2002). However, in the study conducted by Wang & Ju, DS indicated that locomotor skills (jump, running, etc.) of individuals are lower from normal developmental individuals (Wang & Ju, 2002) (Marchala et al., 2016; Van Gameren-Oosterom et al., 2011), again in the study conducted by Hartman et.al. In addition, it is reported that more positive developments (perceptual performance, motor development, general cognitive skills, etc.), mentally retarded individuals between the ages of 8 and 11 were followed for 4 years and at the end of the fourth year the physical fitness parameters in terms of their genders were compared. As a comparison between the sexes and the explosive force (jump force), the normal development group showed improvement, there was no significant difference (Hartman et al., 2015). Also, Cameli et al. in their study they compared the muscle strengths of individuals with mental retardation (MR) only to those with Down syndrome + mental retardation (DSMR); DSMR found that individuals' muscle strength was lower than only MR individuals (Carmeli et al., 2002; Covelli, Raggi, Meucci,

Paganelli & Leonardi, 2016). This suggests that the development of muscular strengths, especially in DS individuals, is even more important. Therefore, while emphasizing the need to improve muscle strength of all DS individuals, we can indicate that exercises improve explosive strength, especially for DS male subjects, should be performed more often than DS female subjects. In addition to these studies, it has been reported that low values of leg strength of DS individuals may have negative effects on daily living activities and job opportunities of these individuals (Sharav & Bowman, 1992; Pitetti et al., 1992). Therefore, we believe that it would be more appropriate for men to work on lower extremity strength skills than girls, by specialized sports trainers or work-seeking physiotherapists.

There was no significant difference between age groups of DS individuals and lower-extremity jump-force tests (horizontal-vertical jump) ($p > 0.05$). Hartman, Smith, Westendorp and Visscher, (2015) in the work they do; physical fitness parameters were compared with age groups (8-11 years) of mentally retarded individuals. There was no significant difference between mentally retarded children (Hartman et al., 2015), while a significant improvement was observed in the control group with normal development between age groups and explosive strengths. There was no significant relationship between age groups and jump strength in our study. For this reason, we can say that both mentally retarded and DS individuals need to work on muscle strength.

When DS individuals were assessed by age, upper extremity strength tests, Although the mean values of DS individuals between the ages of 18-24 were better than the other groups (13-17 years and 25-34 years old), no statistically significant difference was found between them ($p > 0.05$). Priosti et al. reported that there was no significant difference between the age groups of DS individuals (7-9 and 14-15 years) and handicapped persons. However, there was a significant difference in hand skills in the normally developing control group (Priosti et al., 2013). Furthermore, when the fine motor performance and functions of DS individuals aged 2 years were evaluated in the same study, and skills and visual motor integration needs to be improved. In this context, we can emphasize the need for DS individuals to work on the development of fine and coarse motor skills that they use in everyday life. Also, Cuesta-Vargas and Hilgenkamp (2015) focused that when the hand grip strengths are evaluated in terms of the age groups of the individuals with normal development and mentally handicapped, it is seen that the mean grip of handicapped individuals is close to each other according to age groups (Cuesta-Vargas & Hilgenkamp, 2015). We can also emphasize that the reason for not making a meaningful difference compared to the age groups in handcrafting tests, especially in handcrafting tests, is that the hand skills of DS individuals show similarity between ages.

4. Discussions

There are many studies in the literature aimed at improving muscular strength of DS individuals. In these studies, DS individuals (30-70 years old) were given 3 days a week for 12 weeks and 45 minutes. Exercise program; Muscle strength (39% lower extremity and 40% upper extremity) and durability improved

cardiovascular fitness (Rimmer et al., 2004), while body weight did not change significantly (30 min cardio study, 15 min force study). Again, resistance exercises have shown that DS individuals develop muscle strength (Weber & French, 1988). In a study performed by Tsimaras and Fotiadou, the effects of a 12-week training program on muscle strength and dynamic balance of DS individuals (25 females: 15 studies, 10 controls) were investigated. The study group reported that maximal torque forces, isokinetic muscle endurance, and dynamic balance skills of DS subjects were better than the control group (Tsimaras & Fotiadou, 2004). In Shields & Taylor's study, 10-week progressive resistance exercises applied to DS individuals (17 males, 6 females, age 15.6 ± 1.6 years) developed lower extremity strength but did not improve upper extremity strength (Shields & Taylor, 2010). It has been emphasized that exercise programs for large muscle groups 2-3 days a week at 10-12 weeks made by DS individuals are a significant improvement in upper and lower extremity strengths (Cowley et al., 2011, Shields et al., 2008, Tsimaras & Fotiadou, 2004; Mendonca et al., 2010). With these studies in the literature, we can say that DS individuals can increase muscle strength especially with age which does not develop with age.

5. Conclusions

As a result, DS individuals can improve their physical functions through sportive activities throughout their lives, which can also contribute to the life skills of these individuals. We can suggest that DS male individuals have lower explosive strength than daughters, and that this group is particularly suitable for explosive strength work. We suggested that governments, local governments, civil society organizations and others support the financial and structural special groups such DS individuals for participating to sports and various physical activities.

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