DOI: 10.5114/areh.2020.93614

Original article

Advances in Rehabilitation, 2020, 34(1), 1–12

A – preparing concepts
B – formulating methods
C – conducting research
D – processing results
E – interpretation and conclusions
F – editing the final version

Evaluation of measurement methods in determining muscle strength of down syndrome and typically developing individual

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Received: 2020-02-18
Accepted: 2020-03-07
Published: 2020-03-10

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Abstract

Introduction: The muscle strength problems of Individuals with Down Syndrome (IDS) originate from both congenital hypotonus and joint hypermobility. This affects daily life activities adversely. In medicine, muscle strength measurements are usually performed with Nicholas Manual Muscle Test (NMMT) or with the Manual Muscle Test (MMT) by physiotherapists, whereas, in other fields, scientists have difficulty to find suitable tests for measurement of muscle strength. The aim of this study is to investigate whether alternative tests can be used to assess muscle strength in IDS instead of medical tests.

Material and methods: In the city of Adana of Turkey, 30 IDS from various Special Education and Rehabilitation Centers and 85 Typically Developing Individuals (TDI) from various secondary schools participated in the study voluntarily. Lower extremity strength was evaluated with NMMT, Leg Dynamometer Test (LDT), MMT and 30-second Chair Stand Test (30s-CST). The Mann Whitney U Test and Spearman's Rank Correlation were used in statistical analysis.

Results: By using different methods, it was determined that the lower extremity strength assessment measurements correlated positively with each other. Especially, the 30s-CST correlated with the ratio of 0.62 with LDT, while the LDT correlated with the gluteus maximus Manual Muscle Test (right-left) ratio of 0.66–0.64, respectively.

Conclusion: As a remarkable result, low muscle strength was not measured with NMMT. For this reason, we can emphasize that the muscle development measurements of IDS with low muscle strength should be made by using 30s-CST or LDT with NMMT together.

Keywords: sport, strength, 30s-CST, Manual Muscle Test, Down Syndrome

Introduction

Down Syndrome which is a congenital autosomal malformation, is characterized with growth deficiency and mental delay. It was declared that the main physical features common to Individuals with Down Syndrome (IDS) are hypotonia, ligament laxity and decreased muscle strength. Joint and musculoskeletal abnormalities can affect muscle strength quality [1]. It was indicated that muscle hypotonia reduces the quality of life and especially can affect self-care and academic ability in IDS [2,3]. Most of the clinic problems including the musculoskeletal system, orthopedic, cardiovascular and perception disabilities are seen in IDS. IDS runs into problems in gross motor functions like push-ups and sit-ups and major problems in fine motor skills. Also, it is stated that there is an inability in processes including visual motor integration, muscle strength, agility, and motion reaction time. Studies have shown that IDS have lower muscle strength than Individuals with Intellectual Disability (IDI) or non-IDS or non-IDI [4]. Muscle hypotonia, unstable joint or joint problems can lead to more musculoskeletal problems and impaired gait posture in IDS. Because, the limitation appeared in the musculoskeletal system causes secondary defects and fatigue [5]. In literature studies, it has been reported that the leg strength is an important factor as a determinant of functional skill, physical fitness and gait [6,7]. Moreover, it was indicated that there was a strong correlation between leg strength and oxygen uptake values [8]. Accordingly, it can be emphasized that lower extremity muscle strength has great importance for daily life activities of IDS and in maintaining functional independence [9]. Therefore, trainers, parents and scientists working with IDS are trying to contribute to the development of muscle strength by using lower extremity muscle strength training programs. There are many studies (medicine, sports sciences etc.) in the literature regarding muscle strength related to IDS [1,10,11]. In medicine, strength development follow-ups are performed with expensive and hard to reach device tests such as Nicholas Manual Muscle Test (NMMT) or Manual Muscle Test (MMT) done by a physical therapist. However, scientists studying in other fields such as sport sciences, special education, or child development evaluate the muscle strength measurements; and they have difficulty to find suitable test techniques. Therefore, there are few studies related to muscle strengths of IDS in other areas except medicine [10,11].

The 30-second Chair Stand Test (30s-CST) test and Leg Dynamometer Test (LDT) are considered as alternative tests to measure lower extremity muscle strength of elderly individuals; and also, NMMT and MMT results used in medical field were compared in IDS and TDI. Some researchers conducted validity and reliability studies to use the tests managed in different areas in the measurement of IDS [12]. One of these tests is 30s-CST, especially, this test is used to measure lower extremity muscle strength of older adults [13]. In Hilgenkamp et al.'s test-retest studies performed in older adults with Intellectual Disability, 30s-CST was used and moderate-high correlation was found in test-retest reliability (0.65–0.72) [14,15]. Then, Terblanche and Boer evaluated it according to age categories (18–25 years, 26–35 years, 36–45 years and >45y) [9,16]. However, a comparative study for IDS who are athletes or non-athletes and TDIs was not found in the literature.

Therefore, this study was carried out to determine whether easily available, cost-effective tests can be used as an alternative to the tests used in the medical field. Also, the other aim was to compare different methods of lower extremity muscle strengths of athletes and non-athletes with Down Syndrome and Typically Developing Individuals (TDI).

Material and methods

The study protocol was approved by the Ethics Committee of Cukurova University (approval number and date: 59/2016). Lower extremity muscle strength measurements of all groups were performed with four different test methods 30s-CST, NMMT, MMT, LDT. Validity and reliability studies of 30s-CST were performed on IDS (ICC = 0.94) [4, 13, 15, 16]. 30s-CST on TDI was measured twice with one-week intervals, and test retest values and reliability validity were evaluated (ICC = 0.86). All measurements were applied twice to participants and the best measurement value was recorded. Moreover, all tests were performed at the same time in the morning, and the tests took about 30 minutes. A survey was administered to the parents to determine the demographic characteristics (doing sport situations, how many days in a week and hours, etc) by researchers.

Participants

In the city of Adana of Turkey, 30 IDS (15 male and 15 female) from various Special Education and Rehabilitation Centers and 85 TDI (48 male and 37 female) from various Secondary School participated as volunteers in the study. The study group was divided into two groups as IDS (11 athletes and 19 non-athletes) and TDI (53 athletes and 32 non-athletes).

Inclusion criteria for this study

For IDS: cognitive abilities that allow to follow instructions during test measurements. Absence of any history of congestive heart failure, serious pathology and physical, mental and medical problems. For TDI: Absence of any history of physical, neurological and mental health problems.

Due to the few numbers of IDS in society, thirty IDS individuals took part in our study. For this reason, the numbers of IDS and TDI were found different from each other.

Protocol of Muscle Strength Methods

Nicholas Manual Muscle Test (NMMT) [8,9]: It was reported that NMMT (model 01165) was found as reliable and valid for measurements performed on lower extremity muscle strengths of individuals with mental retardation or non-mental retardation [6,17,18]. Manual Muscle Test (MMT) [1,8,9]. MMT and NMMT Protocols: For MMT, the researcher tells to test how strong the upper limb muscles are in the arms. Individuals sit in an appropriate and comfortable test position. The researcher asks individuals to exert as much effort as possible. The MMT grade is measured on a scale from 0 to 5, such as re-scoring +, –, 3, 3+ according to the force of the researcher. Moreover, the NMMT will measure the strength. Individuals are in the appropriate position for measurement. NMMT is placed for the individual as described above. The individual pushes the researcher as best as she/he can. The researcher matches the force exerted by the person on the dynamometer to ensure that the dynamometer remains constant. The value in Newton is stored in the device. Individuals rest for about 30 seconds [19,20].

30-second Chair-Stand Test (30s-CST): 30s-CST was found reliable and valid for IDS in the literature [13–16]. There was no reliability and validity study of TDI for 30s-CST in the literature. For this reason, the test-retest study was performed for 85 TDI one-week intervals twice by us. According to this test results, Cronbach's Alpha value was measured as 0.86 between first and final measurements. The reliability and validity of the test were determined because of showing high correlation. Lower body strength was assessed with the chair stand test [13]. Participants sat on a straight-backed chair (43.18 cm in height and with no arm rests), feet flat on the floor and arms across the chest. On the signal "Go", the participant rose to a full stand, and then returned to a fully seated position. The score was the number of stands completed in the 30s (two trials) [9].

Leg Dynamometer Test (LDT) (Takei Model): Firstly, the test was shown on the dynamometer by the researcher. In the upright position, the dynamometer was set on the individual knee level of the chain. Participants were asked to pull the dynamometer upward in a position similar to the stand position on the basketball. The reading was recorded in kg [10,11].

Study flow chart is shown at Figure 1.

Statistical analysis

The SPSS 21.0 program was used for statistical analysis. Kolmogorov-Smirnov Test was applied for the normal distribution of variables. However, variables did not demonstrate normal distribution. For this reason, the non-parametric test (Mann Whitney U-Test) was applied. Moreover, Spearman's Rank Correlation analysis was performed. In addition, the results were assessed at a 95% confidence interval, with a significance of $p < 0.05$.

Results

The records of 115 individuals (30 IDS, 85 TDI) were assessed. The mean values of the age, weight, height and Body Mass Index (BMI) are presented in table 1.

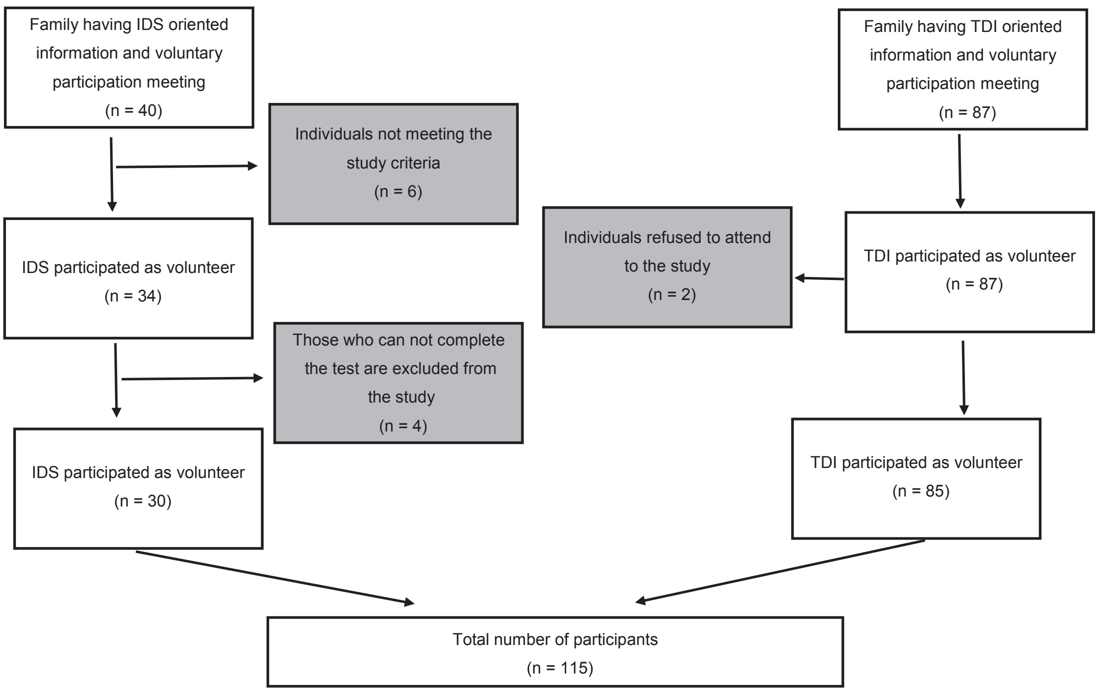

Fig. 1. Study flow-chart

Tab. 1. The demographic characteristics of groups

	TDI			IDS			
Demographic characteristics	n	$\overline{x}$	Sd	n	$\overline{x}$	sd	p
Age	85	12.56	1.91	30	15.90	9.64	0.07
Weight	85	46.55	11.01	30	51.95	22.49	0.216
Height	85	155.12	11.44	30	141.63	16.69	<0.001
Body mass index (BMI)	85	19.18	3.35	30	24.69	7.11	<0.001

TDI – Typically Developing Individuals, IDS – Individuals with Down Syndrome.

Tab. 2. The comparison of lower extremity muscle strength measurements of TDI and IDS

Lower extremity muscle strength measurements	TDI (n = 85)	DSI (n = 30)	z	P
	Mean rank	Mean rank		
30 Second Chair Stand Test	72.08	18.12	–7.645	<0.001
Leg Dynamometer Test	68.06	29.50	–5.452	<0.001
Hip flexion NMMT (right)	66.02	35.27	–4.344	<0.001
Hip flexion NMMT (left)	66.02	35.27	–4.344	<0.001
Hip extension NMMT (right)	65.63	36.38	–4.131	<0.001
Hip extension NMMT (left)	65.83	35.82	–4.239	<0.001
Gluteus maximus muscle (only) NMMT (right)	64.91	38.43	–3.739	<0.001
Gluteus maximus muscle (only) NMMT (left)	65.05	38.03	–3.816	<0.001
Hip flexion manual muscle test (right)	66.38	34.25	–4.716	<0.001
Hip flexion manual muscle test (left)	66.63	33.55	–4.828	<0.001
Hip extension manual muscle test (right)	66.61	33.62	–4.815	<0.001
Hip extension manual muscle test (left)	67.28	31.72	–5.163	<0.001
Gluteus maximus (only) manual muscle test (right)	65.72	36.12	–4.287	<0.001
Gluteus maximus (only) manual muscle test (left)	65.75	36.05	–4.293	<0.001

NMMT – Nicholas Manual Muscle Test; TDI – Typically Developing Individuals, IDS – Individuals with Down Syndrome.

The comparison of lower extremity muscle strength measurements of DSI and TDI were shown in Table 2.

When the lower extremity muscle strength parameters of the participants were examined, there were statistically significant differences in all muscle strength parameters between the two groups ($p < 0.001$). The correlation analysis of four different muscle strength measurement methods of the participants is given in Table 3.

$P < 0.05$ was accepted significant according to Sig (2-tailed) score in Spearman's Rank Correlation analysis. In the evaluation of lower extremity muscle strength measurements performed by using four different methods, it was seen that the measurements showed a positive correlation with each other. It was especially noted that the 30s-CST showed correlation at a rate of 0.62 with LDT, while LDT showed correlation at a rate of 0.66–0.64 with gluteus maximus manual muscle test. While 62.35% of TDI were doing sport regularly, 36.67% of IDS were doing sport regularly. In an examination of sports branches, TDI (28 persons) performed individual sport (karate, gymnastics, cycling, walking, swimming). They reported that they played individual sports for 1.25 ± 0.44 years. Moreover, they also said

Tab. 3. The correlation results of lower extremity muscle strength measurements of two groups

Tests	30s-CST	LDT	HF_{NMMT} (right)	HF_{NMMT} (left)	HE_{NMMT} (right)	HE_{NMMT} (left)	GM_{NMMT} (right)	GM_{NMMT} (left)	HF_{MMT} (right)	HF_{MMT} (left)	HE_{MMT} (right)	HE_{MMT} (left)	GM_{MMT} (right)	GM_{MMT} (left)
30s-CST (r)	1	0.62	0.36	0.38	0.38	0.39	0.33	0.33	0.49	0.48	0.57	0.59	0.50	0.49
30s-CST (p)	<0.001	<0.001	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05	0.009	0.008	0.001	<0.001	0.001	0.001
LDT (r)	0.62	1	0.53	0.53	0.53	0.49	0.54	0.53	0.59	0.59	0.63	0.63	0.66	0.64
LDT (p)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
HF_{NMMT} (right-r)	0.36	0.53	1	0.97	0.84	0.82	0.81	0.77	0.69	0.66	0.66	0.64	0.67	0.62
HF_{NMMT} (right-p)	>0.05	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
HF_{NMMT} (left-r)	0.38	0.53	0.97	1	0.85	0.84	0.81	0.78	0.69	0.69	0.67	0.66	0.67	0.64
HF_{NMMT} (left-p)	>0.05	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
HE_{NMMT} (right-r)	0.38	0.53	0.84	0.85	1	0.98	0.93	0.91	0.69	0.68	0.74	0.73	0.71	0.68
HE_{NMMT} (right-p)	>0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001
HE_{NMMT} (left-r)	0.39	0.49	0.82	0.84	0.98	1	0.92	0.91	0.67	0.68	0.73	0.73	0.71	0.68
HE_{NMMT} (left-p)	>0.05	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
GM_{NMMT} (right-r)	0.33	0.54	0.81	0.81	0.93	0.92	1	0.97	0.66	0.65	0.74	0.73	0.75	0.71
GM_{NMMT} (right-p)	>0.05	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
GM_{NMMT} (left-r)	0.33	0.53	0.77	0.78	0.91	0.91	0.97	1	0.65	0.65	0.75	0.75	0.74	0.71
GM_{NMMT} (left-p)	>0.05	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
HF_{MMT} (right-r)	0.49	0.59	0.69	0.69	0.69	0.67	0.66	0.65	1	0.93	0.82	0.79	0.76	0.72
HF_{MMT} (right-p)	0.009	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
HF_{MMT} (left-r)	0.48	0.59	0.66	0.69	0.68	0.68	0.65	0.65	0.93	1	0.79	0.81	0.76	0.74
HF_{MMT} (left-p)	0.008	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
HE_{MMT} (right-r)	0.57	0.63	0.66	0.67	0.74	0.73	0.74	0.75	0.82	0.79	1	0.97	0.89	0.86
HE_{MMT} (right-p)	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
HE_{MMT} (left-r)	0.59	0.63	0.64	0.66	0.72	0.73	0.73	0.75	0.79	0.81	0.97	1	0.89	0.89
HE_{MMT} (left-p)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
GM_{MMT} (right-r)	0.50	0.66	0.67	0.67	0.71	0.71	0.75	0.74	0.76	0.76	0.89	0.89	1	0.97
GM_{MMT} (right-p)	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
GM_{MMT} (left-r)	0.49	0.64	0.62	0.64	0.68	0.68	0.71	0.71	0.72	0.74	0.86	0.89	0.97	1
GM_{MMT} (left-p)	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

30s-CST – 30-second chair stand test, LDT – Leg Dynamometer Test, NMMT – Nicholas Manual Muscle Test, MMT – Manual Muscle Test, HF – Hip flexion, HE - Hip Extension, GM – Gluteus Maximus; $r < 0.25$ – very weak correlation, $r \geq 0.25$ and $r < 0.50$ – weak correlation, $r \geq 0.50$ and $r < 0.70$; moderate correlation, $r \leq 0.70$ and $r < 0.90$;high correlation, and $r \geq 0.90$ – very high correlation.

Tab. 4. The situations of doing sport in TDI and IDS

			TDI		IDS	
			n	%	n	%
The situations of doing sport in TDI and IDS		Yes	53	62.35	11	36.67
		No	32	37.65	19	63.33
The sport branches	Individual sport	Dance	3	5.66	–	–
		Karate, Judo	3	5.66	–	–
		Bicycle	1	1.89	–	–
		Gymnastics	4	7.55	4	36.36
		Walking	15	28.30	4	36.36
		Swimming	2	3.77	3	27.27
	Team sport	Football	15	28.30	–	–
		Volleyball	2	3.77	–	–
		Basketball	8	15.09	–	–

Groups	TDI (53 Individuals)		IDS (11 Individuals)
The situations of doing sport in participants	Individual Sport (n = 28 TDI) 52.8%	Team sport (n = 25 TDI) 47.2%	Individual sport (n = 11 IDS) 100%
The mean of doing sport year	1.25 ± 0.44 years	2.40 ± 0.50 years	1.82 ± 0.75 years
The mean of doing sport day in a week	3.86 ± 1.76 days	4.00 ± 1.83 days	4.45 ± 1.86 days
The mean of doing sport hours in a day	1.43 ± 0.60 hours	2.08 ± 0.89 hours	1.55 ± 0.52 hours

TDI – Typically Developing Individuals, IDS – Individuals with Down Syndrome.

that they did these sports 3.86 ± 1.76 days a week and 1.43 ± 0.60 hours a day. The rest of TDI (25 persons) were doing team sports (football, basketball and volleyball). They reported that they played team sports for 2.40 ± 0.50 years. In addition, they also declared that they did these sports 4.00 ± 1.83 days a week and 2.08 ± 0.89 hours a day. Moreover, eleven IDS performed individual sport like gymnastics, walking, swimming, etc. (the mean time of doing sport 1.82 ± 0.75 years, 4.45 ± 1.86 days a week and 1.55 ± 0.52 hours in a day) (Table 4).

The comparison of lower extremity muscle strength measurements of TDIs who performed team and individual sport are shown in Table V. Lower extremity muscle strengths of TDIs who performed team and individual sport were compared. According to results, it was determined that the values of 30s-CST (p = 0.03), LDT (p = 0.04), manual hip extension test [right (p = 0.02) and left (p = 0.05)] were higher in TDIs who performed team sport than TDIs who performed individual sports. There were no statistically significant differences in the other test values (p > 0.05) (Table 5).

When the lower extremity muscle strengths were compared in athletes and non-athletes IDS, there were statistically significant differences in the mean values of the athletes with IDS according to non-athletes with IDS [(30s-CST (p =0 .03)], hip flexion NMMT (right) (p = 0.03), Hip Flexion NMMT (left) (p = 0.03), Hip Extension NMMT right (p=0.03), Hip Extension NMMT left (p = 0.02), Gluteus Maximus NMMT left (p = 0.03)] (Table 6).

Discussion

BMI is a health marker. It is commonly used to classify the nutritional status of child, adult and elder individuals [21]. Bertapelli et al formed a BMI chart in Brazil. In this study which was performed on 706 IDS (aged between 2-18 years), the mean of BMI was

Tab. 5. The comparison of lower extremity muscle strength measurements of TDIs who performed team and individual sport

Lower extremity muscle strength measurements	Team sport n = 25 TDI	Individual sport n = 28 TDI	z	p
	Mean rank	Mean rank		
30 Second Chair Stand Test	31.76	22.75	–2.143	0.03*
Hip flexion NMMT (right)	25.72	28.14	–0.570	0.57
Hip flexion NMMT (left)	25.76	28.11	–0.553	0.58
Hip extension NMMT (right)	26.90	27.09	–0.045	0.96
Hip extension NMMT (left)	28.18	25.95	–0.526	0.59
Gluteus naximus NMMT (right)	28.00	26.11	–0.446	0.66
Gluteus naximus NMMT (left)	29.14	25.09	–0.953	0.34
Hip flexion manual muscle test (right)	27.84	26.25	–0.401	0.69
Hip flexion manual muscle test (left)	27.18	26.84	–0.085	0.93
Hip extension manual muscle test (right)	31.96	22.57	–2.337	0.02*
Hip extension manual muscle test (left)	31.14	23.30	–1.944	0.05*
Gluteus maximus manual muscle test (right)	30.72	23.68	–1.714	0.09
Gluteus maximus manual muscle test (left)	29.64	24.64	–1.214	0.23

*p ≤ 0.05, TDI – Typically Developing Individuals, IDS – Individuals with Down Syndrome, NMMT – Nicholas Manual Muscle Test.

Tab. 6. The comparison of lower extremity muscle strength of athletes and non-athletes with IDS

Lower extremity muscle strength measurements	Athletes (n = 11) Mean rank	Non-athletes (n = 19) Mean rank	z	p
30-Second Chair Stand Test	20.09	12.84	–2.18	0.03*
Leg Dynamometer	19.14	13.39	–1.73	0.08
Hip flexion NMMT (right)	19.32	13.29	–1.81	0.07
Hip flexion NMMT (left)	20.05	12.87	–2.15	0.03*
Hip extension NMMT (right)	20.05	12.87	–2.15	0.03*
Hip extension NMMT (left)	20.36	12.68	–2.30	0.02*
Gluteus maximus (only) NMMT (right)	18.86	13.55	–1.59	0.11
Gluteus maximus (only) NMMT (left)	20.00	12.89	–2.13	0.03*
Hip flexion manual muscle test (right)	18.32	13.87	–1.41	0.16
Hip flexion manual muscle test (left)	18.36	13.84	–1.41	0.16
Hip extension manual muscle test (right)	17.95	14.08	–1.19	0.23
Hip extension manual muscle test (left)	18.82	13.58	–1.61	0.11
Gluteus maximus (only) manual muscle test right)	18.09	14.00	–1.27	0.20
Gluteus maximus (only) manual muscle test (left)	18.41	13.82	–1.42	0.16

*p ≤ 0.05, NMMT – Nicholas Manual Muscle Test.

found as 26.14 ± 5.63 kg/m^2 in DS males, respectively. The same dimensions were 26.40±5.92 kg/m^2 in DS females [21]. In our study, the means of BMI of thirty IDS aged between 15.90±9.64 years (15 male; 15 female) were calculated as 24.69 ± 7.11 kg/m^2. According to the literature data, our findings were similar to the studies in Brazilian populations. In our study, there was also a significant difference between TDI and IDS in all parameters excluding age and weight. In a study performed in Japanese population, the relations of muscle strength (lower and upper extremity), BMI, height and weight were examined. In this study performed with 48 Japanese males and 189 Japanese females aged between 15–19 years, it was reported that leg muscle strength was significantly correlated with height and weight ($r = 0.708$ and $p < 0.0001$). However, there was a negative correlation between leg strength per body weight and BMI ($r = –0.719$ and $p < 0.0001$) [22]. All muscle strength parameters were found higher at significant levels in TDI than IDS ($p < 0.001$). We think that the first of reasons why the values of the TDI group are better than the IDS values is that BMI and height values of TDI and IDS groups are different from each other. Moreover, we can say that the second reason is basis physical properties including muscle hypotonia, joint laxity which is seen in IDS. Also, there is a time of prolonged motion, reaction time, balance, postural insufficiency and reduction in co-contraction between agonist and antagonist muscles. For this reason, there are reduced muscle tonus and reduction in ligament laxity in plantar flexor muscles and decreased ankle stabilization [23]. This situation leads to, reduced muscle strength in IDS [1]. In addition, we can say that all these physical characteristics can play a role in low muscle strength in IDS. According to literature performed by Pitetti et al, findings including muscle strength were similar to our study [24]. However, in Golubović et al's Eurofit Physical Fitness Test Battery' study including speed, flexibility, endurance and strength which was performed with 42 Intellectual Disability Individuals (IDI) and 45 TDI, it was reported that all physical fitness parameters were found lower in IDI than TDI. It was stated that this situation is related to the reduced intellectual level [25].

In evaluations of lower extremity muscle strength which was performed with four different methods, the measurements showed a positive correlation with each other. Especially, there was a moderate correlation ($r = 0.62$) between 30s-CST and LDT. There was a moderate correlation between 30s-CST and hip extension muscle strength test right (0.59) and left (0.57), respectively. LDT showed a moderate correlation with gluteus maximus manual muscle test right (0.66) and left (0.64) respectively. Furthermore, there was a moderate correlation between hip extension manual muscle test right and left (0.63). Hardy et al performed a study with 174 individuals (81 males and 93 females, aged 53 years) and reported that 30s-CST showed a negative correlation with weight and height measurements. Moreover, there was a positive correlation between 30s-CST and knee extension muscle strength (quadriceps femoris muscle) [26]. In our study, 30s-CST showed moderate correlation (0.62) with LDT. We can say that while both LDT and 30s-CST were performed, quadriceps femoris, hamstring muscles, dorsi flexors, plantar flexors, erector spina, which play roles in test protocols were used. For this reason, we suggest that LDT and 30s-CST can be used in the strength evaluation of these muscles.

NMMT is one of the muscle tests which we used in muscle strength measurements. There were studies related with reliability and validity of NMMT in literature. The coefficient was found higher than the 0.90 in the reliability study of NMMT (Model 01165) which was performed with having IDI or not. Thus, NMMT was found reliable and valid in muscle strength measurements for individuals [17,27,28]. However, in a study, which was performed one year later by the same researchers there were moderate correlations between NMMT and isokinetic scores. As a result, it was emphasized that the generalization of test results from one test protocol to the other was not assured [18]. In the literature, upper extremity muscle strength correlation coefficients were found between 0.83 and 0.86 in individuals having moderate IDI, and the lower extremity isometric muscle strength correlation coefficient was found higher than 0.79 in individuals with Spastic Diplegic of Cerebral Palsy [17,28]. In addition, there are many studies about different muscle strength measurement devices. These tests were in line with the NMMT usage protocol [27]. In Aufsesser et al.'s study, it was reported that the measurement of hand dynamometers by a fixed lever arm rather than testers' hand can give more reliable results [27]. Therefore, we can emphasize there was the necessity of using such a mechanism in NMMT measurements. Moreover, we can say that at least two measurement protocols instead of one test measurement can be used especially; in lower extremity muscle strength evaluation of IDS. We think that this situation will give more reliable results. In our study, 62.35% of TDIs and 36.67% of IDSs were doing sport regularly. In the investigation of sports branches, twenty-eight athletes with TDI performed individual sport including karate, gymnastics, cycling, walking, swimming, etc. (the mean time of doing sport was 1.25 ± 0.44 years, 3.86 ± 1.76 days a week and 1.43 ± 0.60 hours a day).

Moreover, twenty-five athletes with TDI were doing team sports including football, basketball and volleyball for 2.40 ± 0.50 years and 4.00 ± 1.83 days a week and 2.08 ± 0.89 hours a day. Furthermore, eleven athletes with IDS performed sports like gymnastics, walking, swimming, etc. (the mean time of doing sport was 1.82 ± 0.75 years, 4.45 ± 1.86 days a week and 1.55 ± 0.52 hours a day). Athletes with TDI do both team sports and individual sports, while athletes with IDS do only individual sports. In the literature, IDS participated in both individual and team sports as a recreational activity [24]. In a study performed by Oates et al. on 208 adults with IDS, swimming (44.7%) and bowling (15.9%) as individual sports and football (8.2%), basketball (7.2%) as team sports were done most frequently in Australia [29]. However, in a study performed on 54 adults with IDS by Jobling et al., swimming and jogging were done most frequently by 90% of families [30]. Whereas, IDS tried ice skating in Canada, cycling in Taiwan and China [31,32]. In addition, it was also reported in other studies that walking was performed by IDS most frequently [33,34]. In our study, individual sports were preferred by IDSs as was reported in other literature studies.

In our study, in comparison of lower extremity muscle strength of TDI and non-athletes, 30s-CST ($p = 0.02$) and LDT ($p = 0.03$) results were found higher at statistically significant levels in athletes than in non -athletes. However, in comparison of lower extremity muscle strength of athletes and non-athletes with IDS, the means of some lower extremity muscle strength measurement parameters were higher in athletes than in non-athletes. Furthermore, there were significant differences between groups in some measurements including 30s-CST ($p = 0.03$), hip flexion left ($p = 0.03$), hip extension right ($p = 0.03$), left ($p = 0.02$), gluteus maximus muscle test left side ($p = 0.03$). Jalali et al. compared the fine and gross motor skills of forty athletes and non-athletes with IDS between the ages of 24–33 with BOTMP test. It was reported that sport increased some parameters like running speed, skill and balance in IDS. It was especially emphasized that muscle strength values of athletes with IDS were better than the non-athletes [35]. According to the literature data, our findings were similar to studies in Iranian IDS. Golubović et al. studied measure balance, strength and cardio-respiratory endurance on Serbian population. Their baseline measurements were found lower in 23 mild IDI than in 19 borderline IDI. It was stated that borderline IDI who did exercise received the best results in tests of balance, bent arm hang and cardio-respiratory endurance, while mild IDI received the best results in standing long jump, strength and abdominal muscle strength measurements [25]. Moreover, it was also reported that the IDIs in the control group who were not included in the exercise program had improved in their last measurements and this could be due to the fact that they learned their test positions. However, it was found that the last measurements of IDI in the control group were lower in athletes than IDIs [25]. In our study, there was no significant difference in some strength measurement results. The reason for, this can be explained as follows; Mahony et al. studied 20 physically disabled individuals as Spina Bifida (between 5–15 ages). Their hip flexor, abductor, and knee extensor, the strength of isometric muscle strength were evaluated with a manual hand dynamometer by researchers. It was stated that the intertester reliability interval was between 0.76 and 0.83. In addition, the intertester coefficient for Manual Muscle Test (MMT) of hip abductors, hip extensor and knee extensor were evaluated as high ($r = 0.75$), lower ($r = 0.37$) and lower ($r = 0.40$), respectively. Accordingly, it was stated that if the disabled individuals have insufficient strength to move the lower extremity against gravity, it may be more appropriate to use the MMT [19]. In our study, there was no significant difference in NMMT measurements. We thought the reason for this was that individuals did not apply sufficient strength against gravity. However, there were statistically significant differences in 30s-CST, LDT and MMT results. Therefore, we can emphasize that only the measurement method in force measurement tests may not be reliable and valid in IDS. In another literature study performed with the MMT test, it was important to measure the muscle strength as correct and reliable in IDS and individuals with Developmental Anomaly. Although MMT is a very common method, it was reported that it is controversial to ensure the reliability of force evaluation between normal and good points [36]. For this reason, the 30s-CST is practical and easy to use and we can emphasize 30s-CST can be used as an alternative test for improving the validity and reliability of the test, especially in the lower extremity muscle strength measurements in IDS.

In our study, the lower extremity muscle strength of TDI doing team and individual sports were compared. The results of 30s-CST ($p = 0.03$), LDT ($p = 0.04$), manual hip extension [right ($p = 0.02$), left ($p = 0.05$)] were found higher in those of team athletes than those of individual athletes. There was no statistically significant difference in other muscle strength measurements ($p > 0.05$). It was seen that the articles about muscle strength measurements of subjects who performed team and individual sports were not compatible with each other. In a study performed by Saygın et al., physical characteristics of athletes doing individual sports (47 subjects; athletics, swimming, taekwondo) and athletes doing team sports (113 subjects; football, basketball and volleyball) were compared. It was determined that hand grip strength was better in male athletes doing team sports than in males doing individual sports [37]. According to the literature data, our findings were similar to these. Combined movements (dribble, passing, man to man defense, offensive or defensive techniques, etc.) are more common in team sports than in individual sports. In addition, we can say that team sports need ball more often than individual sports, and this situation plays an important role in increasing overall body muscle strength. However, in a study performed with 15 athletes doing individual sports (athletics, boxing, judo) and 15 team sports (football, basketball, volleyball), physical features were compared. It was reported that the upper extremity muscle strength was found more powerful in individual sports than in team sports [12]. This discrepancy can be originated from limited participation. Generally, we state that the methods of four strength measurements were different in our study. We think that these different results were based on the lack of IDS strength against gravity in some strength tests. In addition, we can say that the co-operation of major and assisting muscles used in some test protocols (30s-CST and LDT) may lead to different results. For example, the gluteus maximus muscle used in muscle strength measurements is the strongest hip extensor muscle [20]. It provides the stabilization of the joint of knee and hip. This muscle works strongest in gait, sit-up, climb up stairs, and upright posture [38]. Moreover, psoas major, psoas minor, and iliacus, which are responsible for hip flexion, abdominal and back muscles, knee extensors and flexors, and ankle dorsiflexors and plantar flexors contribute to movement as accessory muscles in sit-to-stand test [20,38]. If muscle strength is desired to be measured with NMMT, only the strength of the basic muscle involved in that movement is calculated. Thus, we believe that the reason for different results from 4 different methods in muscle strength assessment of the participants is whether or not agonist, antagonist and synergistic muscles (major and assisting muscles) are involved in the measurement evaluation.

Conclusions

In conclusion, we determined that to apply muscle strength measurements together with an alternative test protocol rather than a single test protocol was more realistic and more accurate in our study. Moreover, in the next scientific studies, we suggest that the methods of muscle strength measurements should be chosen according to the aims of measurement. Namely, if the researchers want to measure only one muscle group, they can use the NMMT test. However, we can emphasize that especially in the muscle development measurements of Down Syndrome Individuals with low muscle strength, 30s-CST or LDT with NMMT tests should be used together.

Funding
This research received no external funding.

Conflicts of interest
The authors declare no conflict of interest.

Acknowledgements
The authors would like to thank all of Special Education and Rehabilitation Centers, Secondary Schools and IDS and TDI with their families for their willingness to participate in this study.

References

1. Costa VSF, Silva HM., Alves ED, Coquerel PRS, Silva AR., Barros JF. Hippotherapy and respiratory muscle strength in children and adolescents with Down syndrome. Fisioterapia em Movimento. 2015; 28(2): 373-81.
2. Agiovlasitis S, McCubbin JA, Yun J, Mpitsos G, Pavol MJ. Effects of Down syndrome on three-dimensional motion during walking at different speeds. Gait Posture. 2009; 30(3): 345-50.
3. Pitetti KH, Climstein M, Mays MJ, Barrett PJ. Isokinetic arm and leg strength of adults with Down syndrome: a comparative study. Arch Phys Med Rehabil. 1992; 73(9): 847-50.
4. Lin HC, Wuangb YP. Strength and agility training in adolescents with Down syndrome: A randomized controlled trial. Res Dev Disabil. 2012; 33(6): 2236-44.
5. Dehghani L, Hashemi M, Saboonchi R, Hematfar A, Roonasi A. Relationship between somatotype and some of musculoskeletal deformities of girl students with Down Syndrome. Eur J Exp Biol. 2012; 2(4): 1209-23.
6. Cowley PM, Ploutz-Snyder LL, Baynard T, Heffernan K, Jae SY, Hsu S, Lee M, Pitetti KH, Reiman MP, Fernhall B. The effect of progressive resistance training on leg strength, aerobic capacityand functional tasks of daily living in persons with Down syndrome. Disabil Rehabil. 2011; 33(23-24): 2229-36.
7. Shields N, Taylor NF. A student-led progressive resistance training program increases lower limb muscle strength in adolescents with Down syndrome: a randomised controlled trial. J Phys. 2010; 56(3): 187-93.

8. Rimmer JH, Heller T, Wang E, Valerio I. Improvements in physical fitness in adults with Down syndrome. Am J Ment Retard. 2004; 109(2): 165-74.
9. Terblanche E, Boer PH. The functional fitness capacity of adults with Down syndrome in South Africa. J Intellect Disabil Res. 2013; 57(9): 826-36.
10. Ince G. The effect of 8-week ball-handling training program on upper-lower extremity muscular strength of individuals with Down Syndrome. Eur J Spec Educ Res. 2017; 2(3):88-106.
11. Ince G, Uluöz E. Comparison of Lower and upper extremity strength of individuals with Down Syndrome in terms of age groups and gender. Gymnasium. 2017; 18(1).
12. Perez CA, Lemos IM, Ballesteros1 JL, Carral JC, Camina NL. Reliability and Validity of Physical Fitness Field-Based Tests in Down Syndrome: A Systematic Review. J Policy Pract Intellect Disabil. 2016; 13(2): 142-56.
13. Rikli RE, Jones CJ. Senior fitness test manual. The senior fitness test. The validity, reliability, percentile norms, and criterion referenced standards. USA: Human Kinetics. 2013.
14. Hilgenkamp TI, Van Wijck R, Evenhuis HM. Feasibility and reliability of physical fitness tests in older adults with intellectual disability: A pilot study. J Intellect Dev Disabil. 2012; 37(2): 158–62.
15. Hilgenkamp TI, Van Wijck R, Evenhuis HM. Feasibility of eight physical fitness tests in 1,050 older adults with intellectual disability: Results of the healthy ageing with intellectual disabilities study. Intellect Dev Disabil. 2013; 51(1): 33-47.
16. Boer PH, Moss SJ. Test–retest reliability and minimal detectable change scores of twelve functional fitness tests in adults with Down Syndrome. Res Dev Disabil. 2016; 48: 176-85.
17. Horvat M, Croce R, Roswal G. Intratester reliability of the Nicholas Manual Muscle Tester on individuals with intellectual disabilities by a tester having minimal experience. Arch Phys Med Rehabil. 1994; 75(7): 808-11.
18. Suomi R, Surburg PR, Lecius P. Reliability of isokinetic and isometric measurement of leg strength on men with mental retardation. Arch Phys Med Rehabil. 1993: 74(8): 848-52.
19. Mahony K, Hunt A, Daley D, Sims S, Adams R. Inter-Tester reliability and precision of manual muscle testing and hand-held dynamometry in lower limb muscles of children with spina bifida. Phys Occup Ther Pediatr. 2009; 29(1): 44-59.
20. Otman S, Köse N. Tedavi hareketlerinde temel değerlendirme prensipleri. Ankara: Pelikan Yayınevi. 2015.
21. Bertapelli F, Machado MR, Roso RV, Guerra-Júnior G. Body mass index reference charts for individuals with Down Syndrome aged 2–18 years. Jornal de Pediatria. 2017; 93(1): 94-9.
22. Miyatake N, Miyachi M, Tabata I, Sakano N, Hirao T, Numata T. Relationship between muscle strength and anthropometric, body composition parameters in Japanese adolescents. Health. 2012; 4(1): 1-5.
23. Galli M, Rigoldi C, Mainardi L, Tenore N, Onorati P. Albertini G. Postural control in patients with Down Syndrome. Disabil Rehabil. 2008; 30(17): 1274-1278.
24. Pitetti K, Baynard T, Agiovlasitis S. Children and adolescents with Down syndrome, physical fitness and physical activity. J Sport Health Sci. 2013; 2(1): 47-57.
25. Golubović Š, Maksimović J, Golubović B, Glumbić N. Effects of exercise on physical fitness in children with Intellectual Disability. Res Dev Disabil. 2012; 33(2): 608-14.
26. Hardy R, Cooper R, Shah I, Harridge S, Guralnik J, Kuh D. Is chair rise performance a useful measure of leg power? Aging Clin Exp Res. 2010; 22(5-6): 412-8.
27. Aufsesser PM, Horvat M, Austin R. The reliability of hand held muscle testers with individuals with Spinal Cord Injury. Clinical Kinesiology: J Am Kinesiotherapy Association. 2003: 57(4); 71-5.
28. Crompton J, Galea MP, Philips B. Hand held dynamometry for muscle strength measurement in children with Cerebral Palsy. Dev Med Child Neurol. 2007; 49(2): 106-11.
29. Oates A, Bebbington A, Bourke J, Girdler S, Leonard H. Leisure participation for school aged children with Down Syndrome. Disabil Rehabil. 2011; 33(19-20): 1880-9.
30. Jobling A, Cuskelly M. Young people with Down syndrome: a preliminary investigation of health knowledge and associated behaviours. J Intellect Dev Disabil. 2006; 31(4): 210-8.
31. Sharav T, Bowman T. Dietary practices, physical activity, and body mass index in a selected population of Down Syndome children and their siblings. Clin Pediatr (Phila). 1992; 31(6): 341-4.
32. Wuang Y, Su CY. Patterns of participation and enjoyment in adolescents with Down syndrome. Res Dev Disabil. 2012; 33(3): 841-8.
33. Buttimer J, Tierney E. Patterns of leisure participation among adolescents with a mild intellectual disability. J Intellect Disabil. 2005; 9(1): 25-42.
34. Lin JD, Lin PY, Lin LP, Chang YY, Wu SR, Wu JL. Physical activity and its determinants among adolescents with Intellectual Disabilities. Res Dev Disabil. 2010; 31(1): 263-9.

35. Jalali S, Rad LS, Fahimi S. A Comparison of the gross and fine motor skills of athletes and non athletes with Down's Syndrome. Int J Sport Stud. 2012; 2(1): 31-5.
36. Mercer VS, Lewis CL. Hip Abductor and Knee Extensor Muscle Strength of Children with and without Down Syndrome. Pediatr Phys Ther. 2001; 13(1): 18-26.
37. Saygın Ö, Özsaker M. The comparison of some physical fitness for individual and team athletes. Nigde University J Phys Educ Sports Sci. 2012; 6(2): 102-11.
38. Gaurav V, Singh A, Singh S. Comparison of physical fitness variables between individual games and team games athletes. Indian J Sci Technol. 2011; 4(5): 547-9.