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Effects of powerball on grip strength in children with developmental delay

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Abstract---Objective: Developmental delay refers to the child who attain milestones in a slower time as compared to normal. Compromised grip strength is one of the common issue in these children which restricts them to perform their daily tasks while improvement in body functions, position of elbow and muscle strength can improve the manual dexterity, grip strength and fine motor skills which will help them to perform the daily activities of life. So the study aimed to determine the effects of Powerball on grip strength in children with developmental delay. Methods: Twenty six children with age 7 to 12 years with developmental delay assigned into two groups. Group A received isometric hand grip training exercises while group B received Powerball exercises along with isometrics. 3 sessions per week and total 12 sessions were given and evaluation of grip strength was measured by using hand held dynamometer and ABIL-HAND kids tool. Results: The mean age of children was 10.08 ± 1.49 years while 23.1% (6) children were of age 9 and 12 years each, while there were 61.5% (16) boys and 38.5% (10) girls. Paired Sample T-test and Wilcoxon Signed Ranks tests were used for within group comparison and showed significant improvement in grip strength of the children in both groups (p-value was 0.048 for pre-treatment and 0.007 for post-treatment). Between group comparison was done by Independent Sample t-test and Mann Whitney U-test showed non-significant results as $P\text{-value} > 0.005$. Conclusion: The study concluded that both the interventions showed positive results in desired outcome in respective groups. But in between group comparison, none of them was found to be superior to other.

Keywords---Developmental delay, Dynamometer, Hand grip, Powerball, strengthening exercises.

1. Introduction

Globally, non-lethal injury rate is increasing day by day which does not only restrict daily activities of life but can lead to the mental health issues in a person (Wang, Zheng, Yang, and Wang (2022). Developmental delay refers to the child who does not attains the normal milestones as other children accomplish in the same age within expected period of time or somehow late but can achieve them(Choo, Agarwal, How, & Yeleswarapu, 2019). Children with Developmental delay can present with symptoms like learning and developing issues, talking of talking late, unable to socialize and interact with the environment and difficulty in remembering things and solve problems(Bélanger, Caron, & health, 2018).

If the delay is found in two or more than two areas of the developmental skills, it is known as Global Developmental Delay (GDD). Prevalence of global developmental delay is 1-3% with genetic and structural conditions most commonly found in the children age below year (Mithyantha, Kneen, McCann, & Gladstone, 2017). Global developmental delay could occur independently or in combination with other disorders like congenital, neurological and behavioral problems (Vasudevan & Suri, 2017). In other words we define the delay as “little behind” or “slower to develop”, so the early assessment and management of these children will help to improve the functions (Elia, Coghill, & Health, 2021).

Children with developmental delay can present with behavioral, speech and language, motor skills where fine motor skills (pincer grip, object holding, brushing) and gross motor (rolling over, crawling, clumsy so that trouble in walking) cognition and speech problems. It is mandatory for the parents to check their children if they notice any red flags in their normal milestones achievement. And should contact the right medical person for consultation (Özyurt & Eliküçük, 2018; Vitrikas, Savard, & Bucaj, 2017). Global developmental delay accounts a part of almost all neurological disorders among pediatric population. However, the symptoms are unclear but can be diagnosed by accounting all the domains of developmental skill and can categorize them at different levels of development (Kato et al., 2018).

Milestones cannot be easily measured below the age of 3 years, due to which the prevalence of low to severe symptoms can be seen in these children (Sternäng et al., 2015). Physical exertion level is directly connected to the muscle strength of most organisms but especially in all human beings, as good and well coordinated muscle movement can make life easier (Olczak & Truszczyńska-Baszak, 2022; Valenzuela & Varacallo, 2018). Compromised grip strength can make the children unable to fulfill their daily tasks while improvement in body functions, position of elbow and muscle strength can improve the manual dexterity, grip strength and fine motor skills which will help them to perform the daily activities of life (Demirci & Kartal, 2018). Poor coordination and less stabilization of trunk can cause in-coordination of all muscles of body including wrist and hand muscles. In some studies it is observed that positioning of elbow has great effects on grip strength (Olczak & Truszczyńska-Baszak, 2021; Pitts, Uhl, & Day, 2021).

There are multiple therapies to improve grip strength in children which include strengthening exercises (P. A. Priosti, S. M. Blascovi-Assis, R. Cymrot, D. L. Vianna, & F. A. J. F. e. P. Caromano, 2013b). Use of music has also shown promising results in this regard (Lee, Liu, & Health, 2021). As grip strength is mostly neglected part of strengthening exercises, while it is the most important part to perform the tasks and not to be dependent on anyone, that's why Powerball is used for strength training in different muscles of the body (Amara et al., 2021; Polevoy, 2021). For the well-being of children, parents counseling and their way to carry the follow-up treatment can not only affect their child physical but also mental health (Mas et al., 2019). Parents active participation is required in occupational therapy for improvement of children pinching, grasping and holding (Lin, Lin, & Yu, 2018). In consequences of isometric strengthening of hands, increase or decrease in strength of hands can show the level of healthy activities in children (Mendez-Rebolledo et al., 2022). All the factors affecting pre

and post natal development with social and emotional conditions can decide the muscle strength and working power of a children and their treatment protocol arranged according to these factors (Orsso et al., 2019).

Therefore, the main purpose of this study was to determine the effects of powerball on grip strength in children with developmental delay. Since, hands perform many activities without even thinking and grip strength is a vital indicator in health domain and can be directly related to the daily routine for one, so it is very important to keep hands strong and improve endurance. By using the Powerball, one can improve the wrist and hand muscles strength in developmental delayed children who need someone to help them in performing daily activities. By using dynamometer, pre & post effects of grip strength can be measured in a treatment. Therefore, in spite of many other therapies and techniques used for the strength training, grip strength and palmar grasp in developmental delayed children in school going age can be improve by using Powerball. It would help them to get strengthen and perform tasks as well easily.

2. Methodology

2.1. Study design

This study was Randomized Controlled Trial.

2.2. Duration of Study

The data for Randomized Control Trial were collected for 6 months from DHQ hospital Layyah and Rising Sun Institute for Special Children, Lahore, Pakistan.

2.3. Sample size

Total 26 individuals were included in the study by using Epitool software with level of significance 0.05 by assuming 7.14 attrition rate (P. A. Priosti, S. M. Blascovi-Assis, R. Cymrot, D. L. Vianna, & F. A. Caromano, 2013a).

"Mean 1"	33.26	
"Variance 1"		5.28
"Mean 2"	38.76	
"Variance 2"		9.3
"Confidence Level"	0.99	
"Total Sample size"	26	
Sample size 1	13	
Sample size 2	13	

2.4. Study Groups

Group 1: Control Group, Conventional treatment of physical therapy plan.

Group 2: Experimental Group, Conventional treatment of physical therapy plan along with Powerball exercise.

2.5. Sampling technique: Probability sampling technique was used to collect from DHQ hospital, Layyah and Rising Sun Institute for special Children, Lahore, Pakistan.

2.6. Clinical trial Registry Number: NCT05392296

2.7. Sample selection criteria:

2.7.1. Inclusion criteria:

- Age 7-12 years
- Both genders
- Moderate developmental delay
- Affected fine motor skills

2.7.2. Exclusion criteria

Subjects were excluded if they had,

- Any other neurological condition
- Genetic disorder

2.8. Procedural intervention

After getting informed consent from parents the children were physically examined and parents were asked to fill answer the ABIL-HAND Kids tool according to their children ability to perform their daily activities so that we determine how much their fine motor skills were compromised to fulfill ADL's with low grip strength (Bleyenheuft, Gordon, Rameckers, Thonnard, & Arnould, 2017) Prior to treatment grip strength was checked by hand held dynamometer. The mean of three readings was taken as the fine reading. After the initial assessment the participants were treated according to the allocated groups.

2.8.1. Group 1(Control Group)

In control group or group 1, conventional physical therapy was performed by using isometric hand grip training exercises (putty grip and squeeze exercise, thumb pinch strengthening exercises, isometric Hooks exercises, rubber band abduction and c thumb exercises) for three times in a week for one month. These all activities were performed on both hands individually. First exercise included the use of Putty, subjects were asked to hold the putty in each hand and squeeze it as hard as they could. This exercises was repeated for 2-3 minutes in each session. Second exercise was thumb pinch strengthening, as most of the time thumb is neglected as compared to the fingers, so putty was placed on table in elongated form about 1-2 inches thick, the subject was then asked to pinch it with thumb and index finger one by one. This exercise was repeated for 2-3minutes. Third exercise was isometrics hooks or claws, during this exercise no tool or equipment was required, only isometric contraction was done by the subject to produce maximum voluntary contraction of muscles by using hands. Fingers of both hands were clasped together, and move them in opposite outward position by using arms. The subject was asked to hold this position for 5 seconds and then relax, this movement was repeated 10 times using both right and left hands at top individually. These exerises not only strengthened the fingers but also upper body.Fourth exercise was rubber band abduction exercise, which could improve the intrinsic muscle strength of hands. Rubber band was placed over all four fingers excluding thumb, then subject was asked to spread the

fingers and then relax. This exercise was also repeated for 10-20 times. In the last, c thumb exercise were performed, where a rubber band is placed though all fingers of hands including thumb, and spread the fingers and thumb in C shape, (not in thumbs up shape). Repeated this exercise for 2-3 minutes as it helps to improve dexterity of hand (Garcia-Hernandez, Garza-Martinez, Parra-Vega, Alvarez-Sanchez, & Conchas-Arteaga, 2019).

2.8.2. Group 2 (Experimental Group)

In experimental group or group 2, three sessions per week and total twelve training sessions in a month were performed in these children. In this session, conventional treatment performed with Powerball exercise was done for 3 minutes in a day, where Powerball initially relieved the pain, and then gradually increased the strength and with further improvement made them move in Pain free range. All the muscles of hand, wrist and elbow applied resistance as a result of Powerball movement in hand. All the baseline treatment was combined to find the results (Uttamchandani & Phansopkar).

2.9. Ethical consideration

The study was commenced after the approval of research ethical committee of Riphah college of Rehabilitation and Allied health sciences, Riphah International University, Lahore Pakistan with Ref No. REC/RCR & AHS/22/070

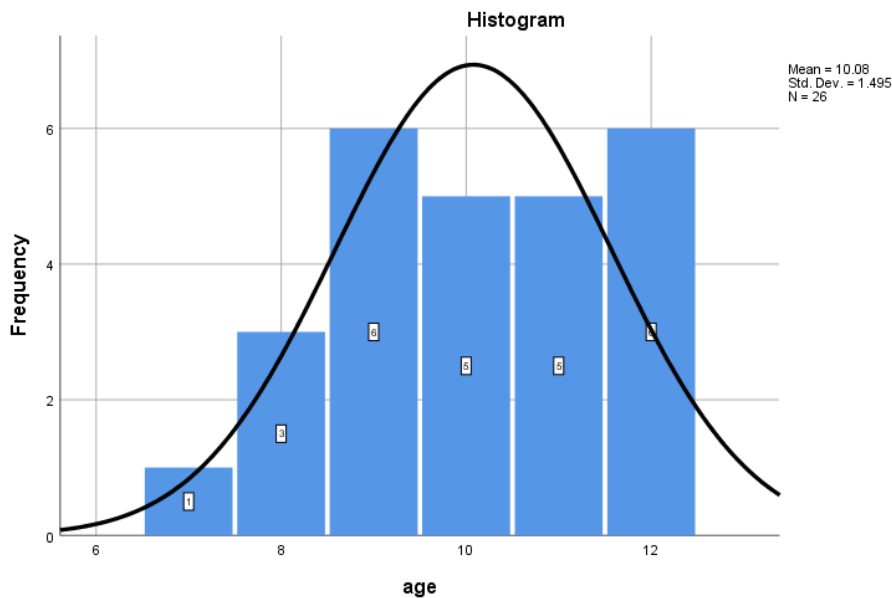
3. Results

3.1. Socio-demographic Data

The study demonstrated that mean age of children was 10.08 ± 1.49 , while majority of the participants were of 9 and 12 years 23.1% (6) each category. While there were 61.5% (16) boys and 38.5% (10) girls included in the study. Of 26 participants 15.4% belonged to Upper class, 76.9% belonged to middle class while 7.7% belonged to Lower class.

Table 3.1: Demographic data

AGE	%age (n)
7	3.8 (1)
8	11.5 (3)
9	23.1 (6)
10	19.2 (5)
11	19.2 (5)
12	23.1 (6)
GENDER	
Boys	61.5 (16)
Girls	38.5 (10)
BODY MASS INDEX (BMI)	
Upper class	15.4 (4)
Middle class	76.9 (20)
Lower class	7.7 (2)

Figure 3.1 Mean $\pm$ SD of age

3.2. Test of Normality

Data analysis showed the significant values of hand held dynamometer were 0.470 which were greater than 0.05 so, the parametric tests were used (between group independent t-test and within group paired sample t-test were used). And data analysis of ABIL-HAND KIDS tool showed significant value of 0.013, less than 0.05 so the non- parametric tests used to find between group by Mann Whitney test and within groups Wilcoxon Signed Ranks Test were used.

Table 3.2 Tests of Normality

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	df	Sig.
Pre value of hand held dynamometer	.105	25	.200*	.963	25	.470
pre value of ABIL-HAND kids	.153	25	.137	.893	25	.013

* This is a lower bound of the true significance.

3.3. Paired sample t-test and Wilcoxon Signed Ranks Test

The researcher intended to find out the effect of both the therapies on individual group so with in group analysis was conducted. The results were non-significant for hand-held dynamometer in both groups as P-value of were 0.21 and 0.77 respectively and the mean and SD of pre-treatment and post-treatment values for control group were 0.81 ± 0.20 and 0.83 ± 0.22 respectively while for experimental group these were 0.85 ± 0.15 and 0.88 ± 0.19 respectively. While the results were significant for ABIL-HAND kids as the p-value for pre-treatment was 0.048 and

that of post-treatment it was 0.007. The Median and mean of pre-treatment as obtained through Wilcoxon Signed Ranks Test in control group was 24.50 & 3.67 while post treatment value in control group was 26.00 and 6.88 and that of in experimental group pre-treatment value for median and mean Rank was 25.00 and 0.00 and post-treatment value obtained was 27.00 and 5.00.

Table 3.3: With in Group Analysis of Hand-held dynamometer and ABIL- HAND Kids

Hand-held dynamometer (Paired Sample t-test)				
		Mean ± SD		P-value
Control group	Pre-treatment value	0.81 ± 0.20		.21
	Post-treatment value	0.83 ± 0.22		
Experimental group	Pre-treatment value	0.85 ± 0.15		.77
	Post-treatment value	0.88 ± 0.19		
ABILHAND Kids (Wilcoxon Signed Ranks Test)				
		Median	Mean Rank	P-value
Control group	Pre-treatment value	24.50	3.67	0.048
	Post-treatment value	26.00	6.88	
Experimental group	Pre-treatment value	25.00	0.00	0.007
	Post-treatment value	27.00	5.00	

3.4. Independent sample t-test and Mann-Whitney U-Test

Between group analysis was done to find out the which group showed much improvement in handgrip strength. The results were non-significant for hand-held dynamometer and ABIL-HAND kids as p-value was >0.05 . The mean and SD of pre-treatment value for control group was 0.81 ± 0.20 while that of experimental group was 0.85 ± 0.15 and for post treatment mean and SD for control group was 0.83 ± 0.22 and for Experimental group it was 0.88 ± 0.19 .

Table 3.4: Between Group Analysis of Hand-held dynamometer and ABIL-HAND Kids

Hand-held dynamometer (Independent Sample t-test)				
		Mean ± SD		P-value
Pre-treatment value	Control group	0.81 ± 0.20		.496
	Experimental group	0.85 ± 0.15		
Post-treatment value	Control group	0.83 ± 0.22		.550
	Experimental group	0.88 ± 0.19		
ABIL-HAND Kids (Mann-Whitney U-Test)				
		Median	Mean Rank	P-value
Pre-treatment value	Control group	25.00	12.42	.701
	Experimental group		13.54	
Post-treatment value	Control group	27.00	11.92	.285
	Experimental group		15.08	

4. Discussion

In the current study, Powerball effects were recorded with hand held dynamometer and used ABIL-HAND Kids tool to find out the muscle strength changes in developmental delay children. This study were in agreement with the previous study done by Paula Aivazoglou Priosti et al. In 2013 were trying to find out correlation between grip strength and manual dexterity in Downs Syndrome children with age 7 to 9 years. By using non randomized convenience technique children were assigned into two groups, in which one was control group and other was experimental group. Jammer dynamometer used for finding out grip strength and Block and box test for manual dexterity. Parametric hypothesis tests were used due to significant results. It was concluded that developmental delay in Downs Syndrome cannot be accessed according to the gender base but with the age, while proper planning to perform the activities is required for further improvement in the muscle strength (Priosti et al., 2013a).

But In this study, researcher choose two groups; in each group 13 children were randomly assigned. Parents were asked to fill the ABIL-HAND kids tool according to their children ability to perform. By using those questionnaires researcher got information about the children affected fine motor skills. And then dynamometer used to check the strength of the hand and record the values. By getting mean of all values it found the final results of the strength. All children got isometric grip strength exercises protocol of physical therapy which were already performing by the children in the hospital but in experimental group researcher used Powerball exercise as additional therapy to the children. Those exercises were performed to improve the strength, as the Powerball tun on and place it on the palm of hand, vibrating body (Powerball) can rotates into palm and its speed can be increased by moving the hand and wrist in circumduction position. Resistance applied as a result on the hand, wrist and elbow. Exercise done for 3 minutes in a day, where Powerball can initially alleviate the pain, then make them feel strong and in the end persons feel strengthen with pain free movements. Like above explained treatment, there were no gender specification for performing any exercise; both male and female took equal part in therapy protocol and children enjoyed the Powerball use for the exercise more blissfully.

Christina Musalek et al. worked to find out physical health wellness by hand grip strength and social factors associated by health related quality of life. Twenty-two men and forty-one women included in study aged between 60-94 years. Personal interviews conducted along WHOQOL-BREF questionnaire were used to find out the hand grip strength. Grip strength were used as a sign for healthy life. Positive results in hand grip strength showed positive effects on physical health and well-being in old aged (Musalek & Kirchengast, 2017) In this study, both significant and non significant results were found for the tools and showing that different factors of social and emotional conditions can effect the HGS. When hand strength is compromised, it will cause decline in hand dexterity and functional activities in individuals.

Jakub S. Gašior et al. performed hand grip strength test in school going children with sample size 135 aged 5 to 9 years. Where dynamometer was used to measure strength, all students could perform three maximum contractions of each hand to

find out the strength on three handle progression positions from first to last. The results showed that Mean $\pm$ SD achieved for HGS in position one was 9.9 ($\pm$ 3.1) kg, 10.4 ($\pm$ 3.1) kg with position two, and 9.0 ($\pm$ 3.2) kg with position three. Shows that second handle position measures maximum in normal healthy children 73% (Gašior, Pawłowski, Williams, Dąbrowski, & Rameckers, 2018) But in this study, it observed that pre and post values of dynamometer and ABIL-HAND kids were both significant and non significant and there were some positive response from the subjects. Dynamometer readings showed the grip strengthening in all subjects and Powerball values in pre and post test and their ability to improve the strength.

Another study in agreement were conducted by Polevoy G.G. et al. in 2021 to find out the effects of speed and strength training in school going children. Case control study was conducted, where control group students attended the physical education and while exercises were included in experimental group along with education. Results showed that control group improved nervous system by 4% ($p>0.05$), whereas in children's, it indicated as high 3% ($p>0.05$) with weak nervous system. In the intervention group, robust nervous system by 18% ($p<0.05$) improved in school children and 14% ($p<0.05$) with weak nervous system children. Hence, Strength and speed training can improve the attention in children (Polevoy, 2021) According to the statistical analysis, in this study small sample size and short time period may contains less but significant results of improvement in developmental delayed children. Questionnaire filled by the guardian or parents showed that most of the children were unable to apply a force to squeeze as compared to the other peers with same age. And they have less power to fulfill their daily tasks. Both the groups were showing positive effects on children but more results were observed in the experimental group where conventional treatment applied with Powerball exercises.

5. Conclusion

This study investigated the effects of Powerball on grip strength of developmental delay subjects and the study showed the significant improvement in both groups. The present study supported the use of both conventional treatment of grip strength and Powerball exercise as protocol physical therapy measure as both techniques are effective in treating grip strength issues in developmental delay (without any condition). The results of this study concluded that use of Powerball with routine physical therapy is also effective to improve grip strength and their functional abilities.

References

- Amara, S., Barbosa, T. M., Negra, Y., Hammami, R., Khalifa, R., & Chortane, S. G. (2021). The effect of concurrent resistance training on upper body strength, sprint swimming performance and kinematics in competitive adolescent swimmers. a randomized controlled trial. *International Journal of Environmental Research and Public Health*, 18(19), 10261.
- Bélanger, S. A., Caron, J. J. P., & health, c. (2018). Evaluation of the child with global developmental delay and intellectual disability. 23(6), 403-410.

- Bleyenheuft, Y., Gordon, A. M., Rameckers, E., Thonnard, J. L., & Arnould, C. (2017). Measuring changes of manual ability with ABILHAND-Kids following intensive training for children with unilateral cerebral palsy. *Developmental Medicine & Child Neurology*, 59(5), 505-511.
- Choo, Y. Y., Agarwal, P., How, C. H., & Yeleswarapu, S. P. J. S. m. j. (2019). Developmental delay: identification and management at primary care level. 60(3), 119.
- Demirci, A., & Kartal, M. J. E. j. o. p. (2018). Sociocultural risk factors for developmental delay in children aged 3–60 months: A nested case-control study. 177, 691-697.
- Elia, A. M., Coghill, J. J. P., & Health, C. (2021). A practical guide to assessing and investigating developmental delay. 31(9), 335-339.
- Garcia-Hernandez, N., Garza-Martinez, K., Parra-Vega, V., Alvarez-Sanchez, A., & Conchas-Arteaga, L. (2019). Development of an EMG-based exergaming system for isometric muscle training and its effectiveness to enhance motivation, performance and muscle strength. *International Journal of Human-Computer Studies*, 124, 44-55.
- Gąsior, J. S., Pawłowski, M., Williams, C. A., Dąbrowski, M. J., & Rameckers, E. A. (2018). Assessment of maximal isometric hand grip strength in school-aged children. *Open Medicine*, 13(1), 22-28.
- Kato, K., Mizuno, S., Inaba, M., Fukumura, S., Kurahashi, N., Maruyama, K., . . . Negishi, Y. (2018). Distinctive facies, macrocephaly, and developmental delay are signs of a PTEN mutation in childhood. *Brain and Development*, 40(8), 678-684.
- Lee, L., Liu, Y.-S. J. I. J. o. E. R., & Health, P. (2021). Training effects and intelligent evaluated pattern of the holistic music educational approach for children with developmental delay. 18(19), 10064.
- Lin, C.-L., Lin, C.-K., & Yu, J.-J. (2018). The effectiveness of parent participation in occupational therapy for children with developmental delay. *Neuropsychiatric Disease and Treatment*, 14, 623.
- Mas, J. M., Dunst, C. J., Balcells-Balcells, A., Garcia-Ventura, S., Giné, C., & Cañadas, M. (2019). Family-centered practices and the parental well-being of young children with disabilities and developmental delay. *Research in developmental disabilities*, 94, 103495.
- Mendez-Rebolledo, G., Ruiz-Gutierrez, A., Salas-Villar, S., Guzman-Muñoz, E., Sazo-Rodriguez, S., Urbina-Santibáñez, E., . . . Guzman-Muñoz, E. J. J. o. E. R. (2022). Isometric strength of upper limb muscles in youth using hand-held and hand-grip dynamometry. 18(3), 203-213.
- Mithyantha, R., Kneen, R., McCann, E., & Gladstone, M. J. A. o. d. i. c. (2017). Current evidence-based recommendations on investigating children with global developmental delay. 102(11), 1071-1076.
- Musalek, C., & Kirchengast, S. (2017). Grip strength as an indicator of health-related quality of life in old age—a pilot study. *International Journal of Environmental Research and Public Health*, 14(12), 1447.
- Olczak, A., & Truszczyńska-Baszak, A. J. B. S. (2022). Motor Coordination and Grip Strength of the Dominant and Non-Dominant Affected Upper Limb Depending on the Body Position—An Observational Study of Patients after Ischemic Stroke. 12(2), 164.
- Olczak, A., & Truszczyńska-Baszak, A. J. J. o. C. M. (2021). Influence of the Passive Stabilization of the Trunk and Upper Limb on Selected Parameters of

- the Hand Motor Coordination, Grip Strength and Muscle Tension, in Post-Stroke Patients. *10*(11), 2402.
- Orsso, C. E., Tibaes, J. R., Oliveira, C. L., Rubin, D. A., Field, C. J., Heymsfield, S. B., . . . Haqq, A. M. (2019). Low muscle mass and strength in pediatrics patients: Why should we care? *Clinical Nutrition*, *38*(5), 2002-2015.
- Özyurt, G., & Eliküçük, Ç. D. (2018). Comparison of language features, autism spectrum symptoms in children diagnosed with autism spectrum disorder, developmental language delay, and healthy controls. *Archives of neuropsychiatry*, *55*(3), 205.
- Pitts, G., Uhl, T. L., & Day, J. M. J. J. o. H. T. (2021). Grip strength is more sensitive to changes in elbow position than isolated wrist extension strength in patients with lateral elbow tendinopathy. *34*(3), 509-511.
- Polevoy, G. (2021). The Effect of Speed and Strength Training on the Indicators of Attention Stability of Children Aged 13-14 Years with different Typologies. *International Journal of Pediatrics*, *9*(4), 13343-13348.
- Priosti, P. A., Blascovi-Assis, S. M., Cymrot, R., Vianna, D. L., & Caromano, F. A. (2013a). Fuerza de prensión y destreza manual en el niño con Síndrome de Down. *Fisioterapia e Pesquisa*, *20*, 278-285.
- Priosti, P. A., Blascovi-Assis, S. M., Cymrot, R., Vianna, D. L., & Caromano, F. A. J. F. e. P. (2013b). Fuerza de prensión y destreza manual en el niño con Síndrome de Down. *20*, 278-285.
- Sternäng, O., Reynolds, C. A., Finkel, D., Ernsth-Bravell, M., Pedersen, N. L., Dahl Aslan, A. K. J. A., & ageing. (2015). Factors associated with grip strength decline in older adults. *44*(2), 269-274.
- Uttamchandani, S., & Phansopkar, P. A Research Protocol to Evaluate the Efficacy of Powerball versus Mulligan Mobilization with Movement on Pain and Function in Patients with Lateral Epicondylitis.
- Valenzuela, M., & Varacallo, M. (2018). Anatomy, Shoulder and Upper Limb, Hand Interossei Muscles.
- Vasudevan, P., & Suri, M. J. C. M. (2017). A clinical approach to developmental delay and intellectual disability. *17*(6), 558.
- Vitrikas, K., Savard, D., & Bucaj, M. (2017). Developmental delay: when and how to screen. *American family physician*, *96*(1), 36-43.
- Wang, Y., Zheng, L., Yang, J., & Wang, S. J. S. (2022). A Grip Strength Estimation Method Using a Novel Flexible Sensor under Different Wrist Angles. *22*(5), 2002.