

COMPARISON OF UPPER-LIMB STRENGTH IN WHEELCHAIR USERS AND NON-WHEELCHAIR USERS WITH PHYSICAL IMPAIRMENTS

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ABSTRACT

The current research was an attempt to compare muscular strength of the upper limb between non-wheelchair and wheelchair users with physical impairments. Purposive sampling method was used to select 20 students aged 10-17 years in PSRD School consisting of 5 wheelchair users and 15 non-wheelchair users. The methodology was a quantitative, comparative research approach, which was school based. A need-based assessment was carried out by Manual Muscle Testing (MMT) to assess upper-limb muscle strengths and individual functional impairments in the baseline and establish the specific training needs before the strength assessment. The Brockport bench press test was then used to evaluate muscular strength in upper limbs. The SPSS was used to analyze the data through descriptive statistics (means and standard deviations) and non-parametric inferential analysis. The sample size was of small size and the data were not normally distributed; therefore, tau-U was employed to determine the difference in muscular strength of the arms of wheelchair users and non-wheelchair users in the upper limbs. The findings indicated that there were statistically significant differences in upper-limb muscular strength among various movements with the findings of non-wheelchair users having a higher muscular strength and the wheelchair users having a relatively high muscular strength in the specific upper-limb functions in mobility and daily activity needs. These results indicate the relevance of need-based and personalized physical training programs, which are based on MMT results, to meet the functional differences of wheelchair and non-wheelchair users with physical disabilities.

Keywords: Upper-limb muscular strength, Wheelchair users, non-wheelchair users, Physical impairments, Brockport Bench Press Test, Need-based physical training.

INTRODUCTION

The physical impairment of children and adolescents is commonly linked to the restriction of muscular strength, the functional movement, and engagement in everyday and school-associated physical actions (Hosokawa et al., 2023)). One of these constraints is a decreased upper-limb muscular strength, which is especially important because it has a direct impact on the aspect of independence, self-care, academic attendance, and the quality of life in general (Hossain, 2022). In the students who

have physical impairments, the strength of the upper limbs is important in propelling the wheelchair, transfers, handling objects, and participating in the process of physical education (Poulsen et al., 2025). As a result, the evaluation and improvement of the upper-limb muscular strength are still the key issues of the adapted physical education and rehabilitation programs (Carretti et al., 2024).

The physically challenged students form a heterogeneous group of students, both

wheelchair and non-wheelchair students, with varying functional capacities and movement requirements (Mason et al., 2022). The wheelchair users are highly dependent on their upper limbs to move and perform normal day-to-day activities in their lives, and this can cause strength adaptations of certain muscle groups (Kadhim, 2025). On the contrary, the non-wheelchair users do tend to use both upper and lower limbs in performing functional activities, which may lead to varied patterns of strength development (Biduski, 2023). Although these differences exist, there is a paucity of empirical data available to compare the upper-limb muscular strength of wheelchair and non-wheelchair students in school-aged groups especially in low- and middle-income countries (Barbareschi et al., 2024).

Effective need-based physical training programs targeting the physical impaired students can only be developed with accurate assessment of muscular strength (Author, Year). Manual Muscle Testing (MMT) usually finds application in clinical and educational practices as a pre-assessment instrument used to establish muscle weaknesses, functional deficits and personal training requirements (Nguyen, & Gomez, 2024). Also standardized field-based measures of fitness like the Brockport Physical Fitness Test have been found to provide valid and reliable measures of muscular strength in youth with disabilities (Leale et al., 2025). Especially, the Brockport Bench Press Test is quite known to be suitable in determining the upper-limb muscular strength in both the wheelchair bound and the ambulatory (Lieberman et al., 2024).

Even though the research has already shown the beneficial impact of strength training on the functional outcome in people with physical impairment (Khodadad et al., 2023), there is still a significant gap in the literature regarding the comparison between the upper-limb muscle strength of wheelchair and non-wheelchair users through the application of standardized measurement instruments (Fasipe et al., 2024). Moreover, not many studies combine need-based testing like MMT with objective strength testing to aid in designing individual intervention (Andary et al., 2023). This gap is significant to fill in the evidence-based practice in adapted physical education and rehabilitation.

Thus, the aim of the current research was to compare muscular strength of the upper limbs with the wheelchair users and non-wheelchair users with physical disabilities in terms of Brockport Bench Press Test, which was conducted after the need-based assessment due to the Manual Muscle Testing. This study aims at providing empirical support on the design of individualized and functionally relevant physical training programs on students with physical impairments in schools by establishing the individual differences based on groups and patterns of functional strength.

Significance of the Study

In this paper, the investigator identified the disparities in upper-limb strength in wheelchair and non-wheelchair users with physical impairments. The results may be used to inform personal physical exercise programs in enhancing functional independence and mobility. It also serves as an advocate of evidence-based practices in special education and rehabilitation. In terms of research, the study has methodological importance in that it shows how non-parametric statistical test tau-u can be used in order to test small and non-normally distributed samples in studies related to disability. Moreover, it also offers a basis on the future experimental and longitudinal research on the effectiveness of the individualized strength training interventions on the need-based assessment.

Research Objectives

1. To assess upper-limb muscular strength of wheelchair users and non-wheelchair users using the **Brockport Bench Press Test**.
2. To **develop a physical training program** for wheelchair users and non-wheelchair users.
3. To implement the developed physical training program over a defined intervention period for students with physical impairments.
4. To compare upper-limb muscular strength between wheelchair users and non-wheelchair users using appropriate **non-parametric statistical techniques**.

Literature Review

Upper-Limb Muscular Strength in Children and Adolescents with Physical Impairments

Disability among children and adolescents is mostly presented in the form of reduced muscular strength, impaired functional mobility and incapacitated involvement in daily and school-based physical exercise (Manojlovic et al., 2023). One of such limitations is low upper-limb muscular strength, which is especially important because it has a direct influence on the independence, self-care, academic participation, and the general quality of life (Akbarfahimi, 2021). The functions of the upper limbs are vital in accomplishing a broad scope of functional activities such as wheelchair propulsion, transfers, object manipulation and engagement in physical education or recreation (Schambra, 2019). As a result, the role of intervention to measure and enhance the strength of the upper limbs has been a center of attention in the adapted physical education and rehabilitation interventions (Suárez-Iglesias, 2020).

Functional Disabilities in Wheelchair and Non-Wheelchair Workers.

The physically impaired students form a heterogeneous group of students physically impaired both as wheelchair users and non-wheelchair users with diverse functional capabilities and mobility needs (Rahman et al., 2025). The wheelchair users usually depend on muscle of the upper limbs to an extent that they are able to move around and carry out their daily living activities and this can lead to selective muscular adjustments of the shoulder, arm and the chest muscles (Rusta et al., 2024). Non-wheelchair users, in turn, use upper and lower limbs in functional activities and, as a result, they may have uneven muscular development and distribution of strength (Craven et al., 2023). In spite of these functional differences, there is still a dearth of empirical research comparing the upper-limb strength of wheelchair users and non-wheelchair users in a school-going population, especially in the low and middle-income countries (Domínguez-Díez et al., 2022). This loophole restricts the possibility of educators and clinicians to develop evidence-based, custom-made physical training plans that meet the needs of a particular group.

Measurement of Upper-Limb Muscular Strength.

The correct evaluation of the muscular strength is a requirement before developing beneficial, need-based physical training programs (Davis et al., 2022). Manual Muscle Testing (MMT) is a relatively common clinical and educational method of determining muscle weakness, functional impairments, and personal training needs (Avers et al., 2024). MMT enables practitioners to formulate customized intervention procedures on the basis of individualized deficits that are manifested in a student. Besides the MMT, there are standardized field-based tests that are reliable and valid measures of muscular strength in youth with disabilities like the Brockport Physical Fitness Test (van Niekerk, 2023). Brockport Bench Press Test, specifically, has been identified to be suitable in the measurement of upper limb muscular strength of both wheelchair and ambulatory individuals (Buhmann et al., 2024). Combination of MMT and objective strength tests offers a holistic model of learning the restricting factors of functional strength and developing a personalized program.

Training Intervention among children with physical impairments Strength Training.

According to research studies carried out earlier, muscular strength, functional capacity, and quality of life of children and adolescents with physical impairments can be promoted using strength training interventions (Manojlovic et al., 2023). Up to now, progressive resistance exercises, task-specific training and adaptive physical education programs have shown positive results in improving upper-limb strength, endurance, and functional mobility (Deng et al., 2022). But the majority of the research concurs on the single-group interventions without the direct comparison of wheelchair and non-wheelchair users, thus, there is limited information concerning the group-specific training adaptations and outcomes. In addition, not many studies include need-based measures like MMT to inform personalized program development, which underscores a major gap in evidence-based practice (Alsarawi, 2023).

Physical Disabilities and Disability.

The spectrum of physical impairments includes cerebral palsy, muscular dystrophy, limb deficiencies, and muscle neuromuscular or musculoskeletal conditions that have an impact on movement and functional performance (Bekteshi et al., 2023). Physically challenged children and adolescents are usually sluggish in developing motor skills, they have lesser muscular strength and are less engaged in physical and recreational activities as compared to their counterparts who develop normally (D'Anna & Pugliese, 2024). Such restrictions can cause secondary health issues, including poor cardiovascular fitness, atrophic muscularity and functional loss of independence (Ahmad et al., 2022).

Significance of Upper-Limb Muscular Strength.

Muscular strength in the upper limbs is one of the determinants of functional independence among the physically impaired people (De Groef et al., 2022). Good upper extremities can assist students to do the necessary tasks which include self-feeding, dressing, writing, transporting things, and also taking part in classroom and physical education works (Zachry & Mitchell, 2024). In the case of wheelchair users upper limb strength is especially important in terms of wheelchair propulsion, transfers, pressure relief and balance (Ucugul et al., 2022). Lack of upper-limb strength has been linked to the lack of mobility efficiency, fatigue, and risk of musculoskeletal injuries.

Adaptations of Wheelchair Use and Upper-Limb Strength.

The locomotion of wheelchair-dependent people is virtually dependent on their upper limbs hence they have specific adaptations in terms of strength and endurance (Chaikhot et al., 2020). Studies have shown that wheelchair patients tend to have increased strength of shoulder flexors, extenders and elbow extenders as a result of continuous propulsion and transfer exercises (McRoberts, 2025). Nevertheless, overstraining the upper limbs with no proper conditioning can also cause shoulder pain, overuse syndromes and degeneration of the joint. These results point to the necessity of organized strength training programs that will

facilitate a healthy development of the muscles and prevent injuries (Schwank et al., 2022).

Methodology

The current research was a quantitative, school based, comparative design of an experiment with ABA design to determine upper-limb muscular strength among students with physical impairments. This design provided an opportunity to measure the effects at the baseline (A1), after the intervention (B), and during a period of withdrawal (A2), which will give a clear picture of the impact of a need-based physical training program. The study population was a group of students of the age 10-17 years attending PSRD School with and without wheelchairs and with various functional capabilities. The sample size was selected by a purposive sampling method and included subjects that met the inclusion criteria, such as having a physical impairment affecting mobility or strength and the capability to safely engage in upper-limb exercises. They were comprised of 20 students, 5 in wheelchairs and 15 non-wheelchairs. There were no students with severe cognitive and intellectual disabilities, recent upper-limb trauma or those in other highly-organized training courses.

Research Design

The current research utilized a school-based comparative research design that is quantitative in nature in order to study the difference in muscular strength of the upper limbs between wheelchair and non-wheelchair users with physical impairments. This was done to enable objective comparison of two independent groups using standard assessment instruments.

Research Setting

The research was done in PSRD School, a learning institution among students with physical impairments. The school-based environment offered a familiar and controlled environment, which guaranteed safety and accessibility of the participants in the process of assessment procedures.

Participants

Purposive sampling technique was adopted to select a total of 20 students with physical impairments whose age was between 10 and 17

years. The sample size used was 5 wheelchair users and 15 non-wheelchair users. Inclusion criteria: (a) PSRD School enrolment, (b) physical impairment diagnosis, (c) good comprehension and ability to follow simple instructions, (d) clearance to engage in physical activity by medical experts. Those students who had severe cognitive disability or acute medical problems were not included in the study.

Need-Based Assessment

There was a need-based assessment before the strength testing in terms of Manual Muscle Testing (MMT). MMT was done to examine the strength of major upper-limb muscle groups at baseline (shoulder flexors and extensors, elbow flexors and extensors, and wrist muscles). The test was recommended to determine the individual muscle weakness of the participants, the functional limitations and the individual training need of the sample.

Evaluation of Muscular Strength of the Upper Limb.

Brockport Bench Press Test was used to measure upper-limb muscular strength as a standardized part of the Brockport Physical Fitness Test that was created to measure youth with disabilities. The test was conducted in standardized protocols, with the participants completing as many correctly done repetitions as possible with an age and ability-based resistance. The cumulative successes of the repetitions were taken as the performance score.

Data Collection Procedure

Data was collected in a standardized way. Data were collected applying an ABA (baseline-intervention-withdrawal) design over 12 weeks. The Brockport Bench Press Test was applied to

assess upper-body muscular strength under standardized setting. Students lay in a supine position on a flat bench with feet supported (or secured for wheelchair users). Participants were instructed to lower the barbell to the chest and then press it up until the arms were fully unfolded. The movement was performed in a disciplined manner following appropriate technique. Each student completed as many correct repetitions as possible without rest. The total number of correctly performed repetitions was listed as the final score. The test was conducted by the researcher with the assistance of trained personnel to ensure safety, correct form, and consistency.

Statistical Analysis

For the analysis of the single-subject experimental design, the Tau-U statistic was used to evaluate the effect of the intervention across different phases of the study (baseline, intervention, and withdrawal). The Tau-U values, Z-scores, p-values, and confidence intervals were calculated to determine the magnitude and statistical significance of the intervention effect, and the level of statistical significance was set at $p < .05$.

Ethical Considerations

Data collection was done after obtaining ethical approval of the institution concerned. The administration of the school was approached and the parents or guardians of all the participants were approached and informed consent was taken. Participant confidentiality and anonymity were ensured during the study and all the procedures carried out within ethical principles of conducting research on human participants.

Table 01 Characteristics Of Students with Physical Impairments

Demographic feature	Category	<i>n</i>	%
Age	10-13 Years	11	55.0
	14-17 Years	9	45.0
Type of Disability	Cerebral Palsy	10	50.0
	Polio	1	5.0
	Muscular Dystrophy	7	35.0
	Other	2	10.0
Wheelchair User	Yes	5	25.0
	No	15	75.0

Table 01 presents the demographic characteristics of the students with physical impairment. In terms of age, the majority of students were in the 10-13 years range (55.0%).

The majority of students were with cerebral palsy (50.0%), and the majority of students were not wheelchair users (75.0%).

Table 02 Comparison of Baseline (A1) Upper-Limb Muscular Strength Between Wheelchair Users and Non-Wheelchair Users

Group	N	Mean Rank	Sum of Ranks	U	Z	P
Wheelchair Users	5	3.00	15.0	0.000	-3.279	0.001
Non-Wheelchair Users	15	13.00	195.0			

Table 02 show The Tau-U test was conducted to determine the comparison between the upper-limb muscular strength of the wheelchair users and non-wheelchair users with physical impairment in the baseline (A1 stage). The result of the analysis showed that the difference between the two groups is statistically significant, $U = 0.000$, $Z = -3.279$, $p = .001$ (two-tailed). Mean

Rank of non-wheelchair users (Mean Rank = 13.00, $n = 15$) was considerably high than that of wheelchair users (Mean Rank = 3.00, $n = 5$), because, at the baseline level, non-wheelchair users were significantly stronger in their upper limbs. The total difference in ranks ($U = 0.000$) indicates a high group difference in the performance of baseline strength.

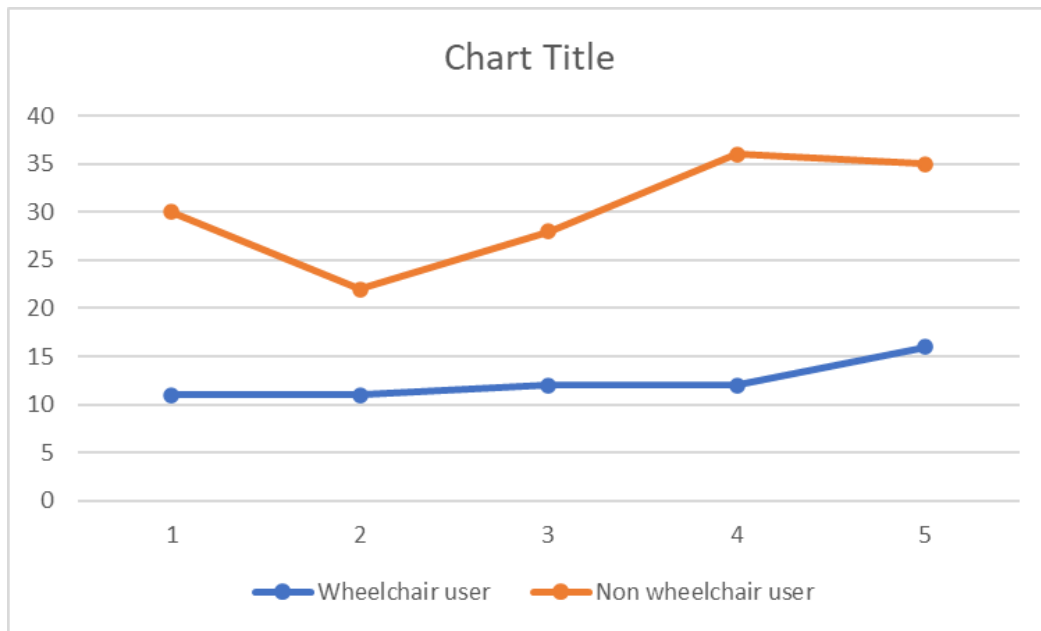


Figure 01 Comparative Performance of Wheelchair Users and Non-Wheelchair Users on the Brockport Bench Press Test During the Baseline Phase (A1)

Figure 01 shows that non-wheelchair users demonstrated higher upper-limb strength than

wheelchair users during the baseline phase, consistent with the statistical findings.

Table 03 Comparison of Intervention (B) Upper-Limb Muscular Strength Between Wheelchair Users and Non-Wheelchair Users

Group	N	Mean Rank	Sum of Ranks	U	Z	P
Wheelchair Users	5	3.00	15.0	0.000	-3.276	0.001
Non-Wheelchair Users	15	13.00	195.0			

As indicated in Table 03, the tau-U test was done to determine the differences in muscular strength of the upper limbs of wheelchair users and non-wheelchair users with physical impairments during the B phase. The results showed that the difference between the two groups was statistically significant, $U = 0.000$, $Z = -3.276$, $p = .001$ (two tailed). The average rank

occupancy of non-wheelchair users (Mean Rank = 13.00, $n = 15$) was very high than the occupancy of the wheelchair users (Mean Rank = 3.00, $n = 5$) which showed that non-wheelchair users exhibited much higher muscular strength of the upper limb. The overall rank difference ($U = 0.000$) is an indication of a high group difference in muscular strength performance.

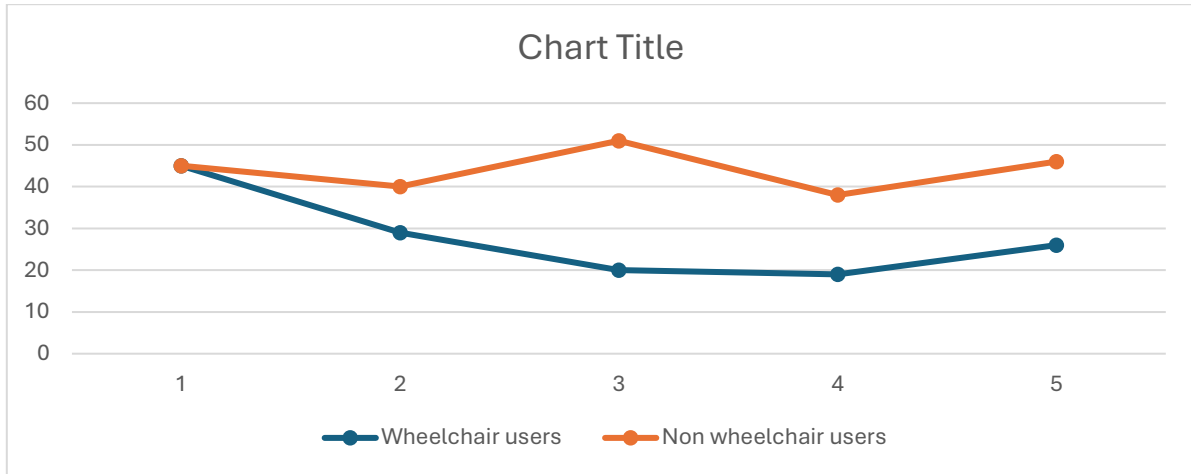


Figure 02 Comparative Performance of Wheelchair Users and Non-Wheelchair Users on the Brockport Bench Press Test During the Intervention Phase (B)

Figure 02 shows that non-wheelchair users demonstrated higher upper-limb strength than

wheelchair users during the intervention phase, consistent with the statistical findings.

Table 04 Comparison of Intervention (B) Upper-Limb Muscular Strength Between Wheelchair Users and Non-Wheelchair Users

Group	N	Mean Rank	Sum of U Ranks	Z	P	
Wheelchair Users	5	4.90	24.50	9.500	-2.448	0.014
Non-Wheelchair Users	15	12.37	185.50			

As illustrated in Table 04, the tau-U test showed that there was significant difference in the upper-limb muscular strength between wheelchair users (Mean rank = 4.90) and non-wheelchair

users (Mean rank = 12.37) at Phase A2, $U = 9.50$, $Z = -2.448$, $p = .014$ (two-tailed). Muscular strength was found to be higher in non-wheelchair people than in wheelchair people.

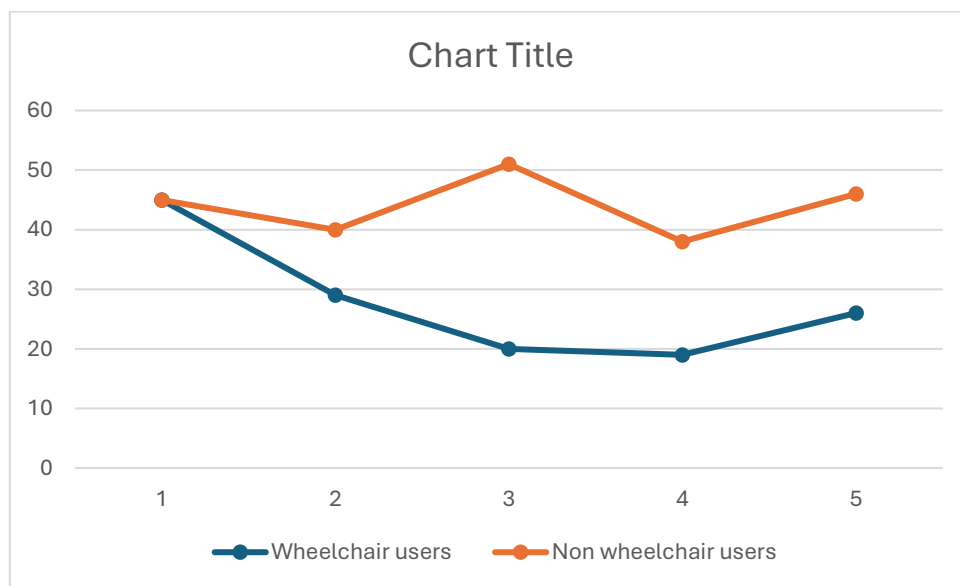


Figure 03 Comparative Performance of Wheelchair Users and Non-Wheelchair Users on the Brockport Bench Press Test During the withdrawal Phase (A2) of the ABA Design

Figure 03 shows that non-wheelchair users demonstrated higher upper-limb strength than wheelchair users during the withdrawal Phase, consistent with the statistical findings.

Findings

The demographic study demonstrated that most students who had physical impairments were 10-13 years (55.0%), cerebral palsy (50.0%), and are not wheelchair-bound (75.0%).

Finding The upper-limb muscular strength of wheelchair users and non-wheelchair users was compared with the tau-U test at various study stages.

Baseline Phase (A1): The muscular strength of the upper limbs between wheelchair users and non-wheelchair users was found to be significantly the same, $U = 0.000$, $Z = -3.279$, $p = .001$.

Intervention Phase (B): There was statistically significant difference between the two groups was maintained, $U = 0.000$, $Z = -3.276$, $p = .001$.

Follow-up Phase (A2): The Mann-Whitney U test showed that there is also significant difference in muscular strength during Phase A2, $U = 9.50$, $Z = -2.448$, $p = .014$.

On the whole, the upper-limb muscular strength of non-wheelchair users remained a lot higher than that of wheelchair users at all study phases, which indicates a continuing difference between the baseline and post-intervention levels of performance.

Conclusion

The researchers concluded that physically impaired non-wheelchair users uniformly expressed much more upper-limb muscular strength in comparison with wheelchair users at each and every stage of research (baseline, intervention, and follow-up). This shows that there is continuing discrepancy in performance of both groups in terms of strength, which demonstrates the importance of specific physical training programs, which will enhance the muscular power, especially in wheelchair users. This result highlights the significance of the functional limitations when the interventions are being designed in case of working with physically impaired students.

Recommendations

The research findings showed that physically impaired non-wheelchair users had demonstrated much higher upper-limb muscular strength as compared to wheelchair users at all the stages of the research process, baseline, intervention, and follow-up. This chronic disparity shows that there is a need to have specific interventions to improve muscular strength among wheelchair users. It is advisable that schools and rehabilitation activities should be provided with tailor made strength training programs as per the functional capacities of wheelchair users, with the provision of inclusive physical education to all physically challenged students. In order to keep track of progress and make necessary changes to the program, it is possible to perform regular evaluations based on standardized measurements, e.g. the Brockport Bench Press Test. Furthermore, the research in the future should also investigate the long-term interventions with more participants and pay attention to such aspects as the nature and extent of impairment to gain better insight into differences in muscular strength among physically challenged students..

Limitations

1. Small Sample Size: The participants only consisted of 20 students and this restricts the applicability of the research results to all students with physical disabilities.
2. Uneven Group Distribution: The sample size of the wheelchair users ($n = 5$) was significantly lower than that of the non-wheelchair users ($n = 15$), which could have a significant impact on the statistical strength of the comparisons.
3. Short Duration of Intervention: The intervention period in the study might have been insufficient to achieve long-term effects of muscular strength of the upper limbs.
4. Ineffective Assessment Instruments: The experiment made use of only the Brockport Bench Press Test in order to determine the muscular strength; other concomitant assessments would have given a more profound view of the upper-limb strength.
5. Homogeneity of Impairments: The majority of the participants were cerebrally impaired, and this might not have reflected students with other physical deficiencies.

Implications

The results of the research have significant practical and learning implications. To begin with, they note that to increase the upper limb muscular strength and overall functional capacity among the students with physical disabilities, especially wheelchair students, specific physical training programs need to be created. Second, the findings underpin the significance of inclusive and adaptive physical education, which must make sure that all students, irrespective of mobility disorders, will be able to participate in strength-building exercises safely and efficiently. Furthermore, it is also highlighted that regular evaluation and control of muscular strength is of value to inform specific interventions and monitor the improvement or deterioration in conditions over time. Lastly, the results can be used to develop policies and practices in special education and rehabilitation environments to enhance the application of evidence-based practices to enhance physical fitness and quality of life in students with physical disabilities.

Further Research

The future research must focus on bigger and more representative samples of physically impaired students in order to enhance the generalizability of the results. Studies might additionally be done on the long-term outcomes of upper-limb strength training initiatives that incorporate subsequent evaluations to estimate the retention of muscular benefits. Besides, research can also take into account various forms and degrees of physical impairments to gain more insight into the impact of these aspects on strength development and training-related outcomes. Adding several assessment instruments in addition to the Brockport Bench Press Test like functional strength or endurance tests might prove a more detailed assessment of upper-limb performance. Lastly, comparative research that would compare various training modalities or intervention programs may be useful in establishing the most viable methods that would be used to enhance the upper-limb muscular strength of students with physical disabilities.

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