

COMPARISON OF UPPER-LIMB MUSCULAR STRENGTH ACROSS AGE GROUPS IN STUDENTS WITH PHYSICAL IMPAIRMENTS

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ABSTRACT

The functional independence and the ability of students with physical impairments to engage in everyday and school activities require upper-limb muscular strength. It is possible that age-related development can affect the muscular strength, but little research has been done to investigate variations within certain age groups in this group of people. The aim of the study was to compare the upper-limb muscular strength in students with physical impairment of 10-13 years of age and 14-17 years of age. A purposive sampling technique was utilized to select 20 students aged 10-17 years with physical disabilities from (PSRD) Pakistan Society for Rehabilitation of Differently Aabled School. Strength of the upper limbs was measured with the help of Brockport Physical Fitness Test and the collected data were analyzed applying the Tau-U test to compare differences between the two age groups. Results showed that students between the age of 14-17 years exhibited much stronger upper-limb strength than students between 10-13 years, indicating the effect of the age and developmental stage on the muscle performance. These findings highlight that age-specific strength training interventions are necessary to improve physical functioning, autonomy and engagement in physically impaired students.

Keywords: Upper-limb muscular strength, Physical impairments, Age groups, Children and adolescents, Strength training

INTRODUCTION

The strength of the muscles is an important element of physical fitness, and it is a crucial factor in the performance of daily activities, overall mobility, and self-sufficiency (Wołoszyn et al., 2021). In children and adolescents with physical impairment, upward-limb muscular strength in particular, is of high significance, since it directly influences the capability of the self-care process, classroom activities and participation in recreational or sports activities. Weakness of upper limbs may constrain functional abilities, limits involvement in age related activities and adversely affect the overall quality of life (Gane et al., 2018). The growth and development in physical aspects of childhood

and adolescence are tightly associated with muscular strength increase (Manna et al., 2014). During the later adolescence years as children grow past their early adolescence years, muscle mass, neuromuscular coordination as well as the hormones come into play and the result is an improved physical performance. Nonetheless, physically impaired students tend to have even more problems, including a lack of mobility, the inability to practice any physical activity, or neuromuscular constraints that may prevent the natural establishment of strength. That is why it becomes necessary to study strength as a not only general characteristic but also as a

developmental characteristic in terms of age (Asan & Canyurt, 2025).

Past researches have been done on muscular strength of children and adolescents with disabilities although most of them have been generalized in comparison to the general population without taking into consideration age related differences (Legerlotz, 2020). A gap that exists is that there is no study carried out on the difference between the upper-limb strength of younger (10-13 years) and older (14-17 years) students with physical impairments. (Nuzzo & Pinto, 2025). It is important to learn about such differences in order to design some effective, age-specific physical training program that would address the unique needs of every age group (Bartholmy et al., 2025).

Through investigating age-related differences in muscular strength of upper limbs, the study will equip educational, therapeutic, and research professionals with useful information. Individualized interventions can enhance physical performance, as well as participation, independence, and quality of life of physically impaired students (Nguyen et al., 2025). The results can be used as a basis of evidence-based practices in schools and clinical practice to inform the strength development strategies based on the developmental stages (Anbazhagan, 2024).

Significance of the Study

The paper demonstrates the age-related variations in upper-limb strength among physically impaired students and these findings will serve as a guide to the age-sensitive strength training programs. Its results can assist educators and therapists to enhance the ability to be self-sufficient, engagement in everyday activities, and quality of life. It also addresses a gap in the literature as it concentrates on the development of the difference in strength, which can serve as a basis of future interventions and research.

Research Objectives:

1. To determine the muscular strength of upper-limbs of 10-13 years old physically impaired students.
2. To determine upper-limb muscular strength among students with physical impairment who are between 14 and 17 years.

3. To determine the comparison between the upper-limb muscular strength of two age groups and bring out the differences.

4. To offer evidence-based suggestions on suitable strength training programs to be used by students with physical impairments depending on age.

Literature Review

The development of neuromuscular and physical development occurs naturally as children advance in school and thus the strength of upper-limb is different in young children compared to older children (Urbina-Alarcón et al., 2025). Increased muscle mass, better motor coordination, and better neuromuscular efficiency are factors that increase the level of strength in older or more developed students (Ahmadpoor & Bragazzi, 2025). However, in physically impaired children, these developmental differences can be more intense because of the lack of physical activities, slow progress in motor development, or a lower involvement in regular exercises, which can affect the level of baseline strength and functional performance (Vandoni et al., 2024).

It has been demonstrated that children at an older age or with higher school levels generally have higher baseline upper-limb strength than children in lower age groups, which is why functional ability and participation can potentially be enhanced with age (Nuzzo & Pinto, 2025). This eventuality clarifies the significance of class or stage-based tests to determine students that might need early intervention to strengthen and become more independent (Alamdari & Bozorgian, 2022). Unless there are timely and correct interventions, younger or lower-level students are likely to suffer some limitations in their daily tasks, eventual partaking in school activities, and the development of the basic motor skills (Boehler, 2024).

Developmentally relevant and structured strength training programs have been found to increase upper-limb strength and functional independence in physically impaired students (Zachry, & Mitchell, 2024). Resistance exercises, task specific functional training, and progressive overload can be used to enhance muscle force, coordination and endurance to allow children to perform self-care, academic, and recreational

activities more effectively (Sadullayevich et al., 2024). Additionally, these programs may be adjusted to the level of classes or the levels of development, with younger students being exposed to simpler and play-based exercises, and older students being receptive to the harder and more goal-oriented exercises (Biru et al., 2025). Although the advantages of strength training are already proved, there is still a gap in the research on the differences in upper-limb strength of children with physical impairments on a class or school level (Legerlotz, 2020). The vast majority of the studies have been comparing the ages in general or comparing the results of interventions, but not in relation to school progression, and the impact of this progression on the baseline strength, functional capacity, and responsiveness to training (Zhang et al., 2024). The recognition of these differences is important in the development of evidence-based, developmentally appropriate programs with the optimal functional independence, participation, and quality of life of students with physical impairments at different school levels (Strnadová et al., 2024).

Such differences in the strength of upper limbs with age have significant implications on functional independence and participation (Řasová et al., 2024). The capacity to work more every day, at school, and during leisure activities and recreational movements is also characteristic of older children, who can produce more forces and have greater endurance due to their improved muscle mass and neuromuscular coordination (Heister et al., 2023). Conversely, young children or those in early grades are not always good at activities that demand long term work, repetitive activities, or cylindrical skills and this hinders their independence and involvement both at school and home (Elgayar, 2025).

Besides, relationships between age and physical impairments may increase the difference in muscular strength. Children who have impairments that include motor control, muscle tone, or mobility have a slower rate of development of strength, and age is even more of a critical factor when defining baseline capabilities and intervention (Ferrara & Sadowsky, 2024). In the absence of specific assistance, physically impaired younger children might have a cumulative delay in gaining

strength, which might affect future functional factor and life quality (Kumar & Friel, 2023).

It is also emphasized in research that it is necessary that age-based strength training programs are in place. In the case of younger students, it is advised to work with the background strength, motor skills development, and play-based activities that contribute to the muscle endurance, coordination, and confidence development (León-Reyes et al., 2025). In the case of older children and adolescents, progressive resistance, functional exercises and more vigorous exercises should be introduced in the programs in order to achieve maximum strength gains and aid the skills and independence in more involved daily activities (Stricker et al., 2020).

As an example, the research on the strength development in children with cerebral palsy identified that adolescents were stronger in their baseline compared to the younger children even though both groups had certain motor impairments (Darras et al., 2021). It means that age and physical maturation have a strong effect on the baseline muscular capacity and should be taken into account during the planning of interventions (Schmidt-Andersen et al., 2024).

The Strength Training Effectiveness between the Age Groups.

Resistance exercise, progressive overload, functional strength work are some of the ways to achieve upper-limb strength through a structured training program (Hofeliña, 2025). It has been indicated that older children are more responsive to such programs because they gain more benefits in muscle strength owing to their excellent musculoskeletal and neuromuscular development (Tumkur Anil Kumar et al., 2021). The younger children experience fewer absolute gains, but also get the benefit of strength training in the form of motor coordination, muscle activation patterns and early functional independence (Zhang et al., 2024). Intervention in younger age categories is therefore more important in the long-term promotion of physical growth even when short term strength improvement is not pronounced (Azzolino et al., 2021)

Strength Gains and Age Retention.

The age may also affect muscular strength gains in terms of their retention following an intervention. Athletes with higher neuromuscular efficiency and muscle memory tend to keep with respect to higher levels of strength after training withdrawal in older children and adolescents, but younger children might need continuous training to maintain the gains (Faude & Donath, 2019). Such results demonstrate the importance of age-specific follow-up programs to guarantee long-term advantages of strength programs.

Implications of Age-related Strength Differences on Functions.

The practical implications of age-related dissimilarities in the strength of upper limbs in day-to-day activities and involvement include participation and involvement in activities (He et al., 2024). Older students who have better-developed upper-limb muscles can be left to perform more self-care tasks and do more complicated physical and recreational activities, whereas younger students might require more assistance or adaptive solutions (Djordjević, 2021). Through insights gained in these differences, teachers and therapists will be able to formulate age-specific training programs that can incrementally increase strength and functional ability.

Methodology

The current research design was a quantitative comparative study to determine the difference between muscular strength of the upper limb between 10-13 year and 14-17 years old students with physical impairment. Purposive sampling was applied to recruit [insert number] students at PSRD Pakistan Society for Rehabilitation of Differently Aabled School. The inclusion criteria were students aged 10-17 years with diagnosed physical impairments and medical clearance to undertake strength tests and students with recent upper-limb injuries or uncontrolled medical conditions were excluded. The upper-limb strength test involved the Brockport Physical Fitness Test -Bench Press, which is a standardized and validated measurement of children and adolescents with disabilities. Testing under supervision was done by the participants who had undergone the required

warm-up and safety measures after which the number of repetitions taken was noted. The SPSS was used to analyze the data, and descriptive statistics were used to summarize the scores, then the actual difference between the two age groups was found by using Tau-U test that was significant at the $p < 0.05$ level.

Research Design

The research design used to address the objective of the study was a quantitative comparative research design. A comparative study of physical impaired students between 10-13 years and 14-17 years of age was conducted on the differences in upper-limb muscular strength. The methodology was able to compare the level of strengths between two different age groups at one time point. The cross-sectional methodology was used and allowed gathering the objective data on the upper-limb strength by the means of standardized assessment tools. The design is appropriate in determining age differences and offering evidences towards age-specific interventions on physical training programs.

Sample of the study

The sample of this study consisted of 20 students with physical impairments, aged between 10-17 years, selected from PSRD School through purposive sampling. The participants were included based on their ability to safely perform upper-limb strength tests and follow instructions. The sample included both wheelchair users and non-wheelchair users, representing different functional abilities. For comparison, the students were divided into two age groups: 10-13 years and 14-17 years.

Research Instrument

The Brockport Physical Fitness Test -Bench Press were the measures of upper-limb muscular strength, a standardized and reliable assessment tool in the children and adolescent population with physical impairments. The test was done under supervision, and the number of repetitions done correctly was counted to compare the ability of the different age groups. Analysis and Interpretation of Data.

Data Collection and Scoring Procedure

Data were collected over a period of 12 weeks applying an ABA (baseline-intervention-

withdrawal) design. Before opening, permission was taken from parents/guardians, and key information such as age, class, type of disability, and whether the student used a wheelchair was documented. In the first two weeks (baseline), students performed the Brockport Bench Press Test beyond any training to understand their initial upper-body strength, and the number of perfect repetitions was noted. In the time of the next eight weeks (intervention), students followed a structured upper-body exercise program according to their abilities, and the same test was used to observe improvement. In the final two weeks (withdrawal), the training was stopped, and the test was organized again to see whether the strength proceed were maintained. Scoring was established on the total number of correct repetitions, where each repetition required lowering the bar to the chest and pushing it up fully with proper form;

incorrect or incomplete repetitions were not counted. All testing was carried out by the researcher with the help of trained staff to ensure safety and consistency.

Data Analysis and Interpretation

The collected data was compared and analyzed with the help of SPSS with the help of the Brockport Bench Press Test. Mean and standard deviation were used to provide descriptive statistics of upper-limb strength scores of the two age groups (10-13 years and 14-17 years). The Tau-U test was employed to test normally distributed data. The significance of $p = 0.05$ was predetermined, and the results were used to determine the difference in muscular strength of upper limbs according to age. Tables and graphs were used to present the findings in order to give a clear comparison of the results of the two groups.

Table 01 that compares baseline (A1) upper-limb muscular strength across different age groups.

| Group | N | Mean Rank | Sum of U Ranks | U | Z | P |
|-------|----|-----------|----------------|--------|--------|-------|
| 10-13 | 11 | 3.00 | 7.18 | 13.000 | -2.778 | 0.005 |
| 14-17 | 09 | 13.00 | 14.56 | | | |

Table 01 shows the result of the comparison between the baseline (A1) upper-limb muscular strength of the two age groups (10-13 years and 14-17 years) of upper limb muscles using the Tau-U test. There were 11 students in the age bracket 10-13 years and 9 students in the age bracket of 14-17 years.

The findings show that the mean rank of students aged 14-17 years (13.00) was higher than that of students aged 10-13 years (3.00), which means that the older age group has superior upper-limb muscular strength at the beginning of the research. Statistical analysis showed that there is a significant difference

between the two age groups ($U = 13.000$, $Z = -2.778$, $p = 0.005$).

The results prove that the baseline upper-limb muscular strength is highly dependent on the age, and the performance of older students is better. This difference can be explained by the increased physical maturation, muscle growth and neuromuscular coordination in the age group 14-17 years. The findings reveal the significance of age-related variations in the determination of muscular strength and the development of physical training programs in students with physical disabilities.

Figure 01-line graph highlights student 01 betterment in three stages

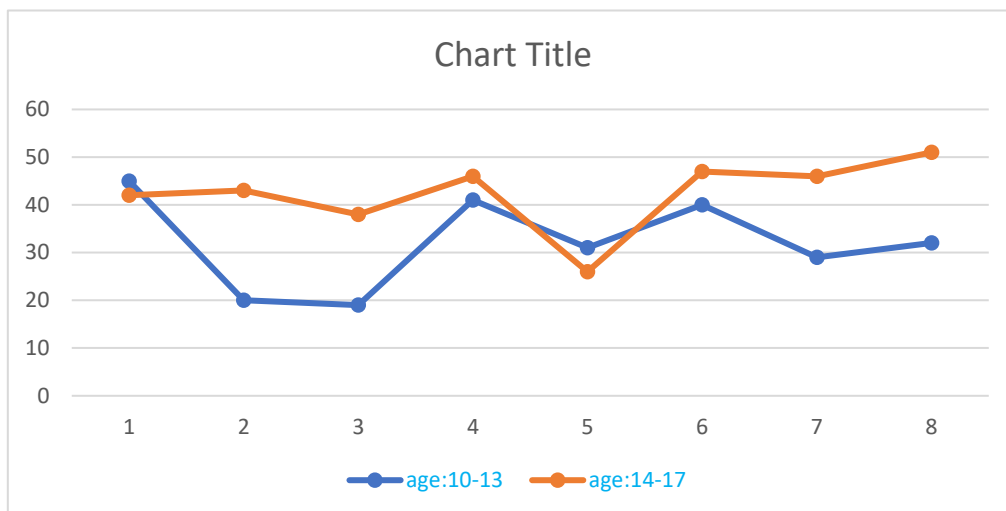


Figure 01- compares baseline (A1) upper-limb muscular strength across different age groups.

The figure explains the 14-17 years age group demonstrates consistently higher muscle

strength scores compared to the 10-13 years age group across most measurement points.

Table 02 that compares Intervention (B) upper-limb muscular strength across different age groups.

| Group | N | Mean Rank | Sum of U Ranks | Z | P |
|-------|----|-----------|----------------|--------|--------|
| 10-13 | 11 | 7.73 | 85.00 | 19.000 | -2.319 |
| 14-17 | 09 | 13.89 | 125.00 | | 0.020 |

Table 02 will contain the comparison of the upper-limb muscular strength of the baselines (A1) of two age groups (10-13 years and 14-17 years) with the help of Tau-U test. There were 11 students in the 10-13 years age bracket and 9 students in the 14-17 years age bracket. The findings indicate that the age group of 14-17 years (13.89) has a higher mean rank than the age group of 10-13 years (7.73) showing that the upper-limb muscular strength of older students is better at the baseline.

The statistical test showed that there was significant difference between the two age

categories (U = 19.000, Z = -2.319, p = 0.020). This observation indicates that age plays a major role in determining baseline upper-limb muscular strength with older pupils in the case being more stronger. The difference observed could be explained by physical maturation of the age group observed, higher muscle bulk and better control of the motor in the 14-17 years age group. These findings demonstrate the necessity to address the issue of age differences in evaluating muscular strength and developing the adequate physical training programs among students with physical disabilities.

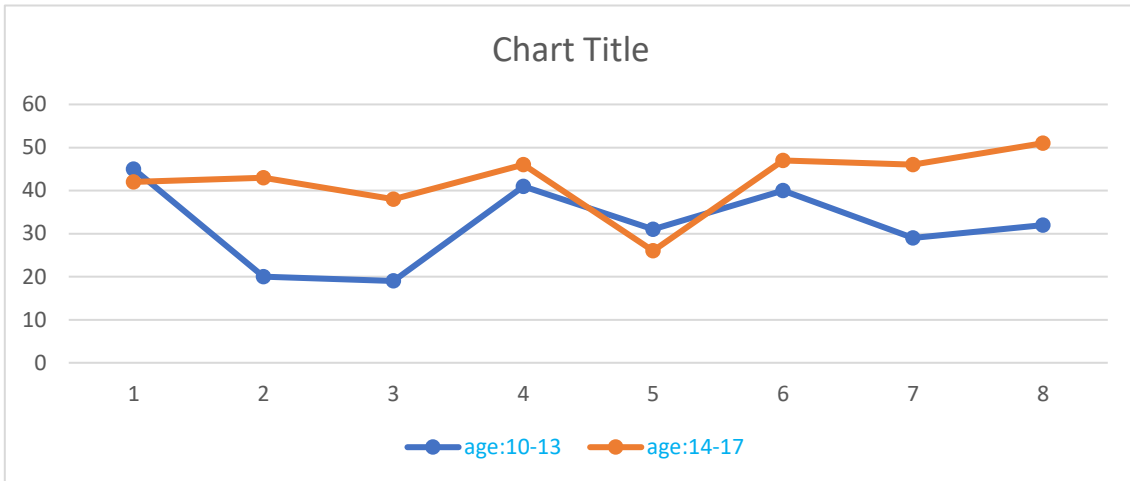


Figure 02- compares intervention (B) upper-limb muscular strength across different age groups.

The figure explains the 14-17 years age group demonstrates consistently higher muscle

strength scores compared to the 10-13 years age group across most measurement points.

Table 03 that compares withdrawal (A2) upper-limb muscular strength across different age groups.

| Group | N | Mean Rank | Sum of U Ranks | Z | P |
|-------|----|-----------|----------------|--------|--------|
| 10-13 | 11 | 7.73 | 85.00 | 19.000 | -2.319 |
| 14-17 | 09 | 13.89 | 125.00 | | 0.020 |

Table 03 is the comparison of upper-limb muscular strength baseline (A1) in two age groups (10-13 years and 14-17 years) with the Tau-U test. The group aged 10-13 years (n = 11) had a mean rank of 7.73 whereas the group aged 14-17 years (n = 9) had a higher mean rank of 13.89 which showed that the older students have better upper-limb muscular strength at baseline. The statistical significance of the difference between the two age groups was observed to be significant (U = 19.000, Z = -2.319, p = 0.020). This finding implies that the baseline upper-limb

muscular strength is greatly affected by age, teenage (14-17-years old) individuals being stronger than 10-13-year-old children. The difference that is observed could be explained by the physical maturation, increment in muscle mass and better neuromuscular coordination in the old group. These results highlight the need to include age-related variations in the estimation of the baseline strength and design physical training interventions to students with physical impairments.

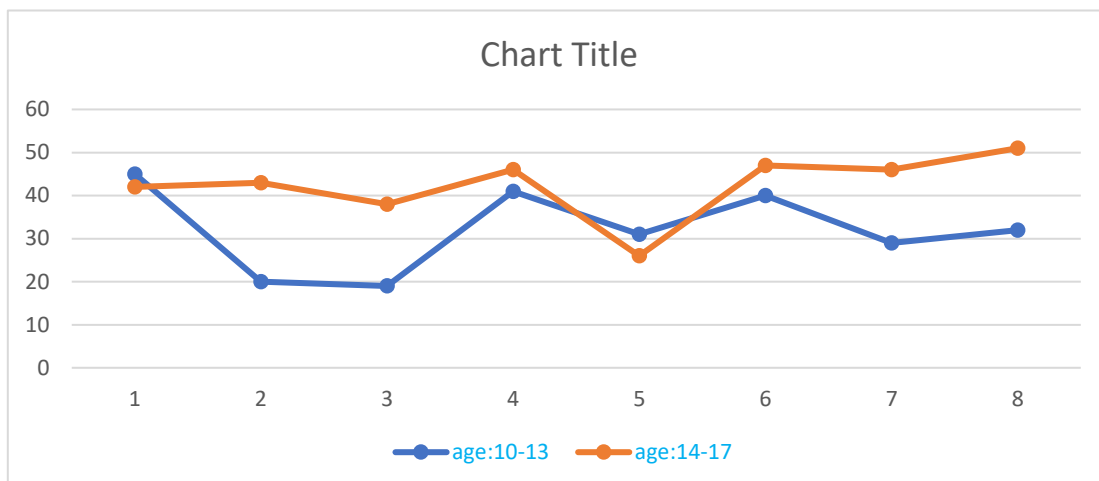


Figure 03- compares withdrawal (A2) upper-limb muscular strength across different age groups.

The figure explains the 14–17 years age group demonstrates consistently higher muscle strength scores compared to the 10–13 years age group across most measurement points.

Findings

The age-specific results regarding the muscular strength of the upper limbs during the Baseline (A1), Intervention (B), and Withdrawal (A2) phases demonstrate the existence of significant differences in the two age groups (10-13 years and 14-17 years). The upper-limb muscular strength of students in the control condition (A1) showed greater strength in students aged 14-17 years than the same in students aged 10-13 years, which means that their age had an age-based advantage before the intervention.

During the intervention stage (B), both age groups demonstrated the positive change in the upper-limb muscular strength, though all the changes were more significant in older age, which indicates the higher the response that the older age group showed to the intervention. This can be explained by the fact that older students have higher levels of physical growth and neuromuscular efficiency.

In the withdrawal phase (A2), there was a small decrease or no change in performance of both age groups. However, the students between the age of 14 and 17 years still had higher levels of strength than the students between the age of 10 and 13 years, which means that the former participants retained strength gains better.

Conclusion

The conclusion made in the study is that the age plays a significant role in upper-limb muscular strength in students with physical impairment in all stages of study (A1, B, and A2). The level of strength at the baseline was always higher in older students (14-17 years) compared to younger students (10-13 years), because of the intervention phase, older students showed greater improvement of the level and continued to perform better at withdrawal phase.

Physical training program was effective in increasing muscular strength of upper limbs in both age groups but the extent of increasing and maintaining the gains was stronger among older students. Probably, these differences can be associated with the maturation of the body and the maturation of neuromuscular activity due to age. On the whole, the results are focused on the necessity to take into account age-related peculiarities when evaluating muscular strength and creating specific training programs that could be offered to students with physical disabilities in order to obtain the best and the most effective results.

Implications

The results of this study can be significantly applied in the development and execution of physical training programs among physically impaired students. Age is a major factor in the upper-limb strength, training response, and maintenance, which shows that training programs are to be age-specific. Elderly students can make superior gains and be more steady, whereas younger students can be provided with

early age-related interventions that can encourage muscular growth and independence. Teachers, counselors, and trainers must keep in mind physical development, muscular development, and age-related requirements when designing exercises and progression programs. Periodic review of the upper-limb strength can be used to monitor the progress, define students that need further assistance, and streamline the results. Comprehensively, the results are consistent with the idea that to promote independence, participation, and quality of life among physically impaired students, age-sensitive and inclusive physical education and rehabilitation should be done to increase the strength of the upper limbs.

Future Research

The next round of studies ought to focus on the effect of age-specific physical training programs on upper-limb muscular strength and functional abilities of students with physical impairments in the long-term. Research has the potential of examining differences in types, severity, and the length of intervention to determine the most effective approach to use in the different age groups. The effects of upper-limb strength training on the quality of life, the level of academic engagement, and daily functioning should be also researched. Greater and more varied samples, encompassing different kinds of physical impairments, would make comparisons show a more in-depth insight into age-related reactions to training. Lastly, longitudinal studies are required to evaluate how strength gains can be retained over time and to establish approaches to sustaining the gains once the intervention is provided to support the evidence-based practice in the physical education and rehabilitation programs.

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