Effect of Elbow Flexors Fatigue on Hand Grip Strength in Physiotherapy Students

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Abstract

Background: Hand grip strength (HGS) is a crucial indicator of overall health and functional capacity, reflecting the combined force generated by the muscles of the hand. For physiotherapy students, strong HGS is essential for performing manual therapy and exercise therapy techniques. Muscle fatigue can adversely affect HGS by diminishing the muscle's force-generating capacity. **Purpose:** This study was conducted to investigate the effect of elbow flexor fatigue on hand grip strength among physiotherapy students. **Materials and Methods:** The study involved 35 adult, non-athletic physiotherapy students aged 18-25 years with a normal BMI (18.5 - 24.99 kg/m²). Participants were required to have a dominant right hand and were recruited based on specific inclusion criteria, ensuring no history of musculoskeletal disorders that could affect upper limb function. Elbow flexor fatigue was induced using a Biodex isokinetic dynamometry system through repeated elbow flexion exercises until a predetermined level of fatigue was reached. Hand grip strength was assessed pre- and post-fatigue using a Jamar hydraulic dynamometer, with three trials conducted for accuracy. Statistical analysis was performed using paired t-tests to evaluate the hypothesis that elbow flexor fatigue does not significantly affect hand grip strength. **Results:** The results indicated a significant reduction in hand grip strength following elbow flexor fatigue among physiotherapy students, with an average decrease of approximately 15% in grip strength post-fatigue compared to pre-fatigue measurements. **Conclusion:** The findings highlight that elbow flexor fatigue significantly reduces hand grip strength in physiotherapy students. This underscores the necessity for physiotherapy programs to implement strategies that enhance

muscle endurance and manage fatigue, ultimately improving manual therapy performance and patient care outcomes.

Key words: Hand grip strength, elbow flexors, fatigue, physiotherapy students, muscle function, manual therapy.

Introduction

Hand grip strength (HGS) serves as a valuable indicator of overall health and functional capacity [12,21]. It reflects the combined force generated by both extrinsic and intrinsic muscles of the hand, which are essential for gripping and manipulating objects [21].

Strong HGS is particularly important for physiotherapy students as their future profession relies heavily on manual therapy techniques that require sufficient force application [18].

Muscle function can be compromised by fatigue, which is characterized by a reduction in force-generating capacity [2,22]. Fatigue can arise from central or peripheral origins; central fatigue involves changes within the central nervous system, while peripheral fatigue originates from alterations at the muscle fiber level.

Regardless of its source, fatigue can significantly impact HGS [9], Research indicates a strong connection between HGS and elbow function[23]. Stronger elbow flexors contribute to greater HGS since maximum grip strength is often achieved with a straight elbow where these muscles are not actively engaged in maintaining posture.

Therefore, understanding how elbow flexor fatigue affects HGS is crucial for optimizing hand function in physiotherapy students.

Statement of the Problem

Does elbow flexor fatigue have an effect on handgrip strength in physiotherapy students?

Purpose of the Study

This study was conducted to investigate the effect of elbow flexor fatigue on handgrip strength in physiotherapy students.

Significance of Study

Physiotherapy students rely heavily on hand function throughout their academic and professional careers. Strong hand grip strength is essential for various tasks, including manual therapy and exercise therapy techniques and also for maintaining writing posture during studies[5,11].

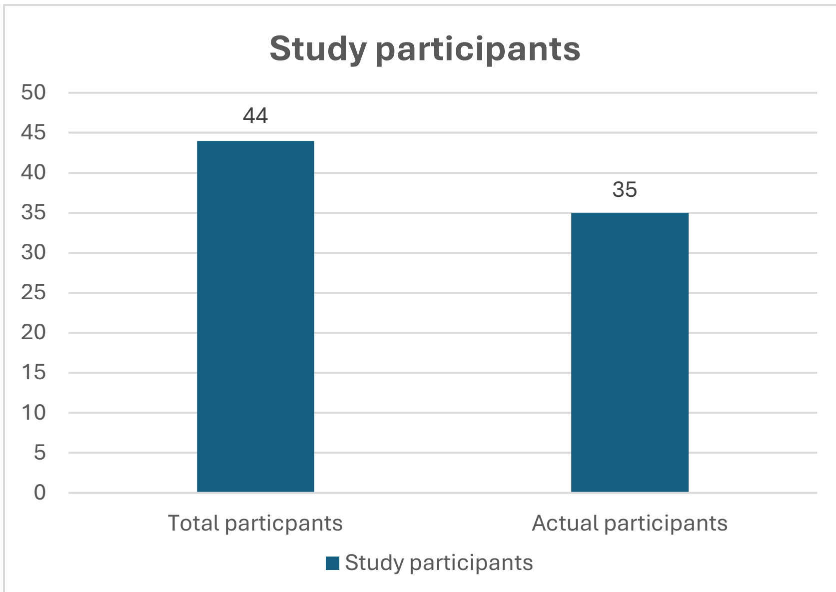
Understanding the relationship between elbow flexor fatigue and HGS can provide valuable insights into optimizing hand function for future physiotherapists and make a significant impact on their future practice.

Study design:

Cross-sectional observational study.

Methodology

Participants



Sample size calculation of the present study was done based on a previous study [1]. G*Power software, version 3.1.9.2 was used as a priori type of power analysis for paired t test. In this study, the primary outcome was hand grip strength. Effect size of 0.49 was utilized and type I error was a maximum of 5%. The power of the test was 80%, making the overall sample size 35. Considering a potential 20% sample drop out, the final sample size wouldreach 44.Participants were recruited using a convenience sampling method.

The study included 35 non-athletic physiotherapy students aged 18-25 years with a normal BMI (18.5 - 24.99 kg/m²). Participants were recruited from college of physiotherapy Misr university for science and technology and the experiments wereconsistent with the Declaration of Helsinki. They were also screened for eligibility based on specific criteria.

Inclusion criteria:

The subjects were selected according to the following criteria:

1. Adult non-athletic physiotherapy students with age range between (18: 25) years old

2. Dominant hand is either the right hand
3. Body mass index between (18.5:24.99) Kg/ m^2.

Exclusion criteria:

The subjects were excluded if they had any of the followings:

1. Traumatic conditions of the upper limb.
2. Previous orthopedic disorders or neurological deficit of the upper limb.
3. Previous surgery of the upper limbs.
4. Any sensory problems.
5. Neuromuscular disease like multiple sclerosis.
6. Pregnancy.
7. Cancer Patients.
8. Immunodeficiency diseases.
9. Psychological disorders (depression - anxiety).
10. Chronic diseases as (diabetes - hypertension)
11. Participants with hand deformity
12. Participants with specific hand muscles weakness

Procedures

Following recruitment from physiotherapy students in Misr University for Science and Technology, participants will provide their demographic data. Body Mass Index (BMI) has been calculated by measuring each participant's height and weight. Individuals with a BMI outside the normal range as defined by **Shrestha et al., 2023[21].** has been excluded to minimize confounding variables. Participants meeting all inclusion criteria are asked to sign an informed consent form

Prior to data collection, participants were familiarized with the equipment and testing procedures. Handgrip strength has been measured three times pre-fatigue using a standardized protocol. The average of these three measurements are recorded.

Following a five-minute rest period, participants have undergone a fatigue protocol using a Biodex isokinetic dynamometer. Handgrip strength have then been measured again post-fatigue using the same protocol, with the average of the three measurements documented.

Hand Grip strength assessment:

The grip power of dominant hand were assessed using a standard adjustable hydraulic handgrip dynamometer.

Participant position:

Upright sitting position with shoulder adducted and neutrally rotated and elbow in 90-degree flexion whereas the forearm natural position on arm rest and wrist was set in slightly extended position.

The dynamometer was held freely without support, not touching the participant trunk. The position of the hand remained constant without downward direction[16].

First, the researcher calibrated the dynamometer to zero and adjusted the hand size. Next, the participant has been asked to perform the testing protocol consists of three maximal isometric contractions for 5 second, on dominant hand, with a rest period of at least 60 seconds and the highest value will be taken for determination of maximal grip power. The participants were instructed to squeeze the dynamometer as hard as possible [13].

Maximum voluntary isometric contraction measurement (MVIC):

Subjects were seated so that the lateral humeral epicondyle was used as the bony landmark to match the axis of rotation of the elbow joint with the axis of rotation of the dynamometer resistance adapter [19].

The elbow angle was 90, with the forearm upright. Three MVICs of 5-s duration were carried out. The MVICs were averaged and this value was taken as the MIVC [24].

Fig. (1): Participant position during elbow MVC measurement

Isokinetic fatigue protocol:

Isokinetic fatigue was used instead of conventional isometric fatigue as isometric contractions might not be demonstrative of incidence of muscle action and fatigue during human activity [8]. This exercise procedure has been previously used and replicates the cellular and efficient processes detected with acute sessions of exercise [4].

Each participant was seated upright in the chair with 90º of hip flexion and secured with padded straps across the shoulders and the waist to minimize auxiliary movements during the fatiguing task [14].

The fatiguing protocol was performed with a load equivalent to 20 % of MVIC because this load (during maximal velocity efforts) corresponds to near peak power (force × velocity) along the force–velocity curve [6].

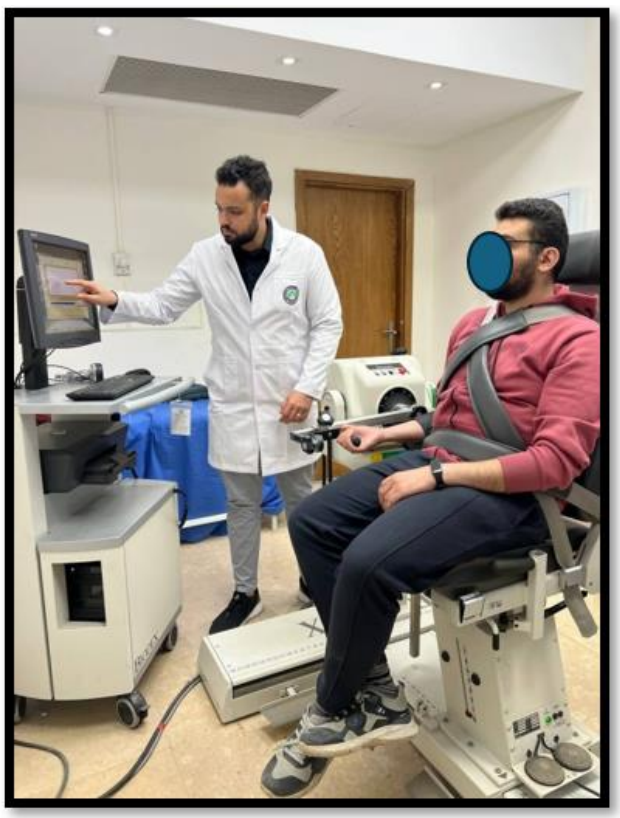


Fig. (2): Participant undergoing the fatigue protocol

Previous study has stated that men and women fatigue similarly during maximal velocity dynamic contractions at the 20% load, eliminating the confounding effects of sex differences in performance or muscle fatigue that is typically observed for isometric fatiguing contractions [10].

Force reduction was provoked using continued maximal concentric and eccentric elbow flexors' actions. Participants were guided to do 3 sets of 20 repetitions of maximal concentric and eccentric contractions. The angular velocity was adjusted at 45 degrees/sec for concentric actions and 60 degrees/sec for eccentric actions. Each participant was guided to do repetitions "as powerful as possible". Oral and visual feedbacks were given throughout the exercise protocol [20].

Fatigue quantification

Fatigue of the elbow flexors was not quantified using questionnaires, as the fatigue protocol was standardized for all participants. Resistance was set at 20% of each individual's maximum voluntary contraction force, ensuring a personalized yet consistent approach. Additionally, all participants were unable to complete an extra set after the fatigue protocol, confirming its effectiveness.

Results

The aim of this study was to investigate the effect of elbow flexors fatigue on handgrip strength in physiotherapy students

Demographic data of subjects:

A total of Forty-four subjects of both sexes, 33 males and 11 females participated in this study. As shown in table (1) and (figures 1-2); the mean values of age, weight, height and BMI of the study group were (22.75±1.89) years, (73.2±9.26), (174.02±8.15) and (23.93±1.22) respectively. The number (%) of males of 33 (75%) and the number (%) of females 11 (25%).

Table (1): Demographic data of subjects of both groups

Demographic data	Study group (n= 36) mean ± SD	Minimum	Maximum
Age (years)	22.75±1.89	18	25
Weight (kg)	73.2±9.26	57	95
Height (cm)	174.02±8.15	158	190
BMI (kg/m^2)	23.93±1.22	20.5	25
Sex	number (%)		
Males	33 (75%)		
Females	11 (25%)		

SD: standard deviation

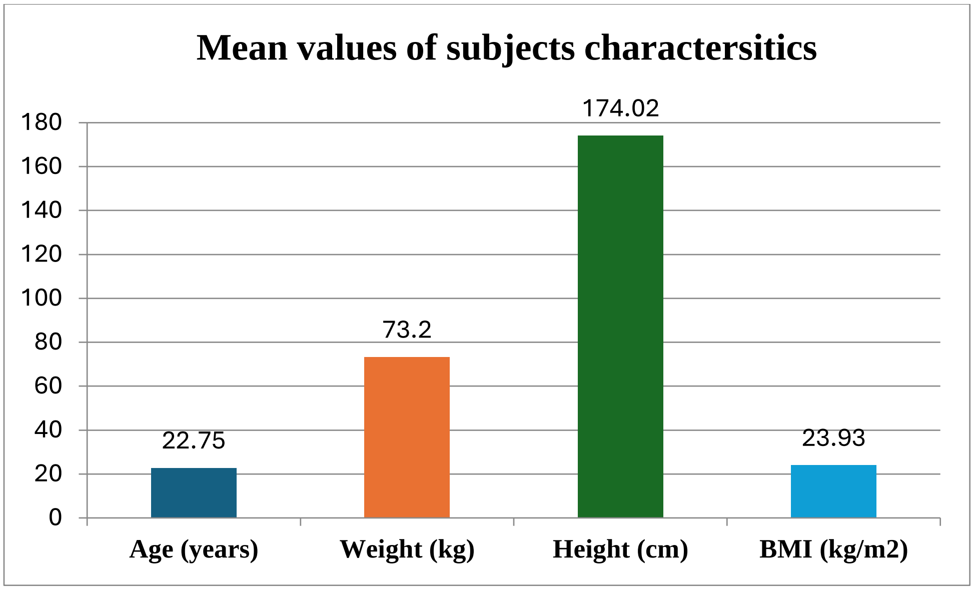


Figure (1): Mean values of subjects' characteristics of the study group

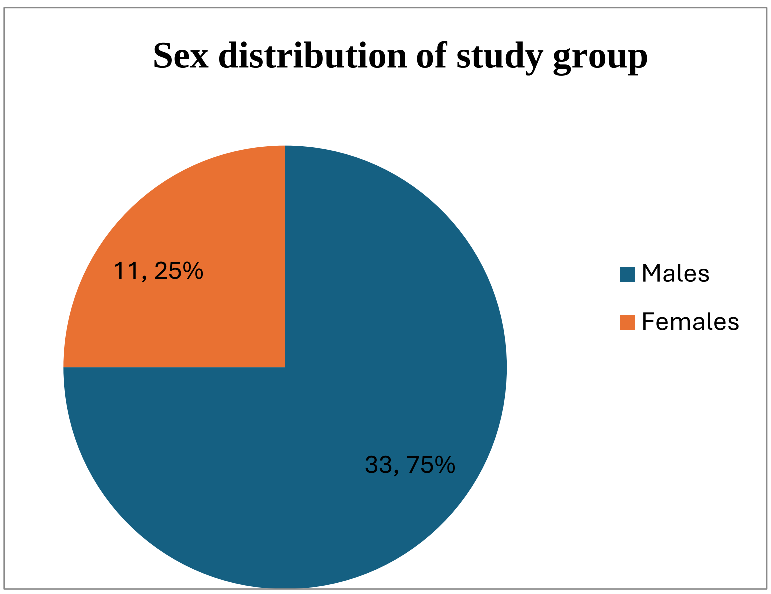


Figure (2): Sex distribution of the study group

Normality test:

Data were screened for normality assumption, homogeneity of variance, and presence of extreme scores. Shapiro-Wilk test for normality showed that MVC was normally distributed (p>0.05).

The impact of fatigue on hand grip strength:

As shown in table (2) and figure (3), the mean values ± SD of hand grip strength of 1st measure pre and post-fatigue of the study group were 39.68 ± 11.6 and 36.94 ± 8.67 newton respectively. There was a statistically significant decrease in hand grip strength post-fatigue compared with that of pre-fatigue by 7% (p = 0.032).

Table (2): Mean ±SD of MVC pre and post fatigue of the study group.

Maximum hand grip	Pre-fatigue Mean ±SD	Post-fatigue	MD (95%CI)	% of change	P-value
1st measure	39.68 ± 11.6	36.94 ± 8.67	2.74 (0.83, 4.64)	7%	0.006*
Minimum	17.5	21.5			
Maximum	63	57			
2nd measure	37.53 ± 9.72	35.78 ± 9.81	1.75 (0.78, 3.34)	5%	0.032*
Minimum	18	19			
Maximum	57	57			
3rd measure	36.25 ± 9.43	34.79 ± 9.2	1.46 (0.14, 2.78)	4%	0.031*
Minimum	22.5	21			
Maximum	56	56			
Average	37.79 ± 9.95	36.48 ± 9.16	1.31 (0.12, 2.49)	3.5%	0.032*
Minimum	19.8	22.3			
Maximum	57.6	57.6			

SD: standard deviation, CI: confidence interval, *: significant

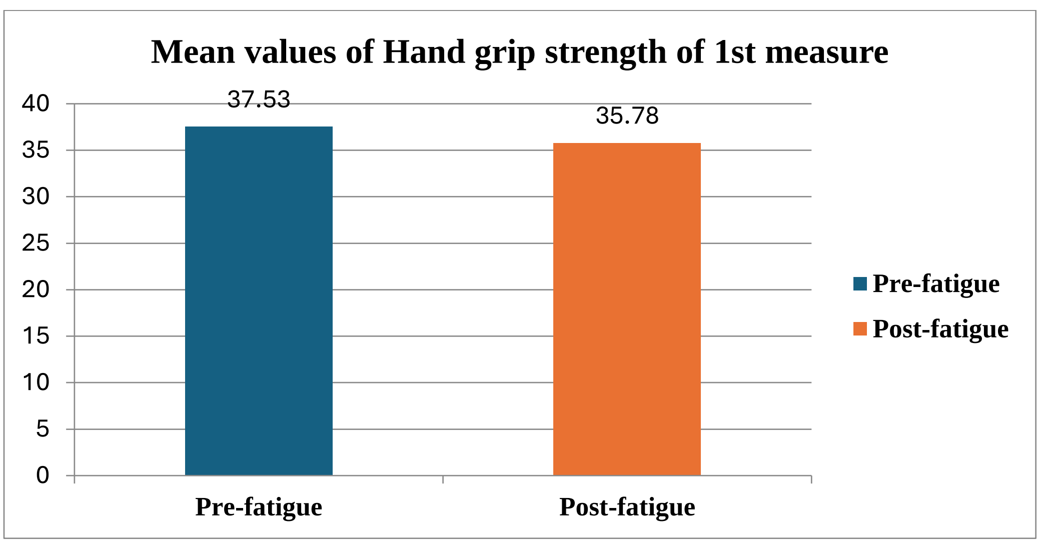


Figure (3): Mean values of hand grip strength pre and post fatigue of 1st measure of the study group

As shown in table (2) and figure (4), the mean values ± SD of hand grip strength of 2nd measure pre and post-fatigue of the study group were 37.53 ± 9.72 and 35.78 ± 9.81 newton respectively. There was a statistically significant decrease in hand grip strength post-fatigue compared with that of pre-fatigue by 5% ($p = 0.032$).

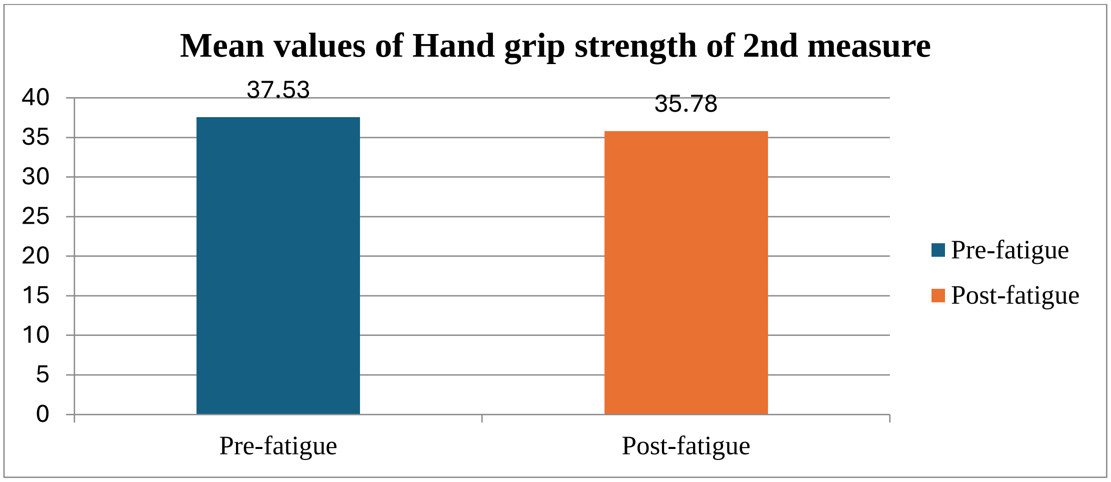


Figure (4): Mean values of hand grip strength pre and post fatigue of 2nd measure of the study group

As shown in table (2) and figure (5), the mean values ± SD of hand grip strength of 3rd measure pre and post-fatigue of the study group were 36.25 ± 9.43 and 34.79 ± 9.2 newton respectively. There was a statistical significant decrease in hand grip strength post-fatigue compared with that of pre-fatigue by 4% ($p = 0.031$).

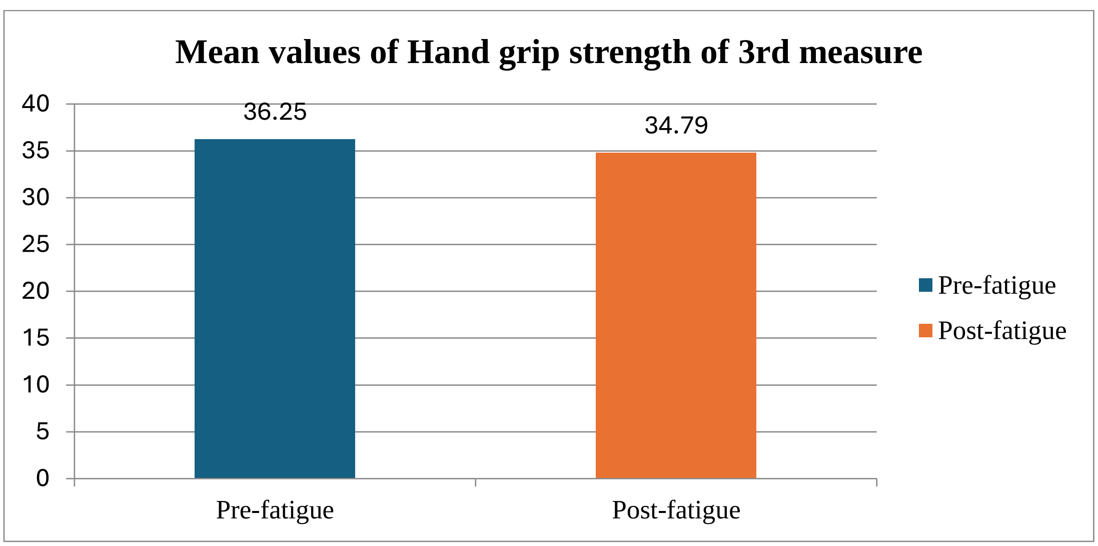


Figure (5): Mean values of hand grip strength pre and post fatigue of 3rd measure of the study group

As shown in table (2) and figure (6), the mean values ± SD of average hand grip strength pre and post-fatigue of the study group were 37.79 ± 9.95 and 36.48 ± 9.16 newton respectively. There was a statistically significant decrease in average hand grip strength post-fatigue compared with that of pre-fatigue by 3.5% ($p = 0.032$).

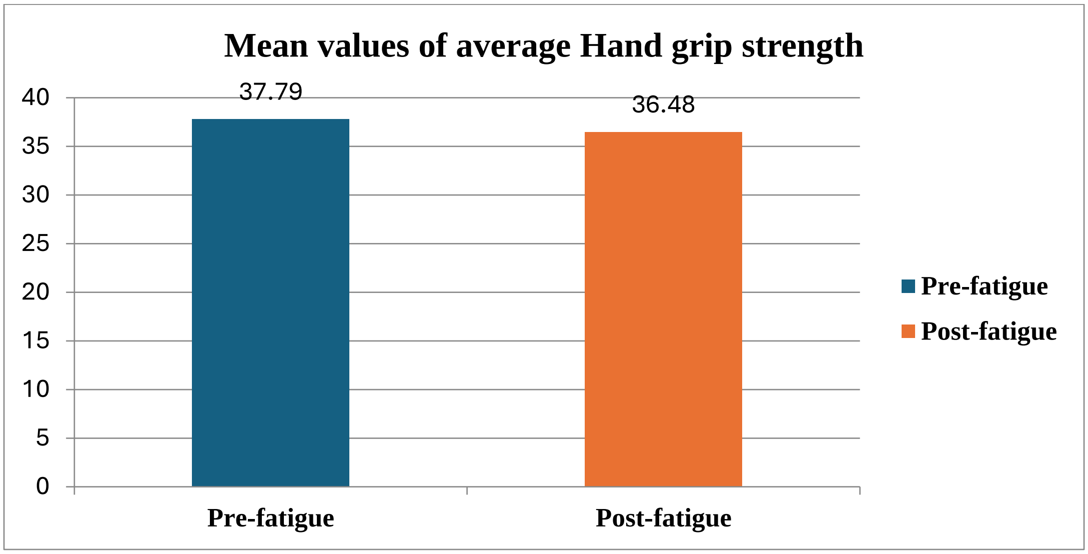


Figure (6): Mean values of average hand grip strength pre and post fatigue of the study group

Discussion

The results corroborate earlier research that has explored the impact of muscle fatigue on HGS. For instance, studies have demonstrated that both central and peripheral fatigue significantly impair maximal voluntary contraction (MVC), which is closely related to HGS [9,17].

Additionally, the current findings resonate with previous research which reported strong correlations between elbow flexor strength and HGS [3,15].

Fatigue alters neuromuscular activation patterns, leading to decreased motor unit recruitment and firing rates during maximal efforts. This phenomenon can be attributed to several physiological mechanisms, including central fatigue, which involves changes within the central nervous system that may reduce voluntary activation levels during muscle contractions, and peripheral fatigue, which originates from alterations at the muscular level—such as depletion of energy substrates (e.g., glycogen), accumulation of metabolic byproducts (e.g., lactate), and impaired calcium handling—that can significantly impair muscle contractility [25].

The implications for physiotherapy students are particularly relevant given their reliance on manual dexterity and strength in clinical settings. As future healthcare providers, they must maintain optimal physical performance while managing their own endurance levels during prolonged activities such as patient handling or therapeutic interventions.

Moreover, factors contributing to increased muscle fatigue among physiotherapy students include prolonged static postures during studying or practicing techniques that strain the elbow flexors over time. These activities may lead to cumulative fatigue effects that could compromise their ability to perform manual tasks effectively during clinical practice [11].

The findings also suggest that educational programs should incorporate training regimens aimed at enhancing muscular endurance and recovery strategies to mitigate fatigue effects on performance.

By addressing these aspects proactively, institutions can better prepare students for real-world challenges they will encounter as practicing therapists.

In conclusion, this study underscores the critical relationship between elbow flexor fatigue and hand grip strength in physiotherapy students. By recognizing how fatigue influences performance outcomes, educators can develop targeted interventions that promote physical resilience among future practitioners.

Limitations

1-Convenience Sampling – The study used a convenience sampling method, which may introduce selection bias and limit the generalizability of the results to a broader population.

2-Homogeneous Sample – The study included only non-athletic physiotherapy students aged 18-25 with a normal BMI, which limits the applicability of the results to other populations, such as individuals with varying fitness levels, older adults, or those with musculoskeletal conditions.

3-Limited Outcome Measures – The study focused solely on hand grip strength without considering other functional measures that may be affected by elbow flexor fatigue, such as endurance or dexterity.

4-Potential Learning Effect – Participants performed multiple grip strength tests, which might have led to a learning effect, potentially influencing the results.

5-Uncontrolled External Factors – Factors such as participants' diet, hydration status, sleep quality, or psychological state were not controlled, all of which could influence muscle fatigue and grip strength outcomes.

Conclusion

Elbow flexor fatigue has a significant negative effect on hand grip strength among physiotherapy students. This underscores the need for educational programs to address muscle endurance training as part of their curriculum to optimize performance in clinical settings.

Recommendations

Future studies should explore interventions aimed at improving endurance in elbow flexors among physiotherapy students to mitigate the effects of fatigue on hand grip strength. Additionally, further research could investigate similar effects across different populations or clinical settings to broaden understanding in this area. This paper synthesizes key elements from your thesis while adhering to academic standards for clarity and coherence.

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