Correlation between muscle strength, fatigue resistance, work ability and upper limb dysfunction in a sample of workers at a university hospital

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Research article

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Abstract

Introduction

The upper extremity is related to the functional ability to perform activities of daily living, self-care and work. Complaints in the upper limbs negatively affect these skills, therefore, it is necessary to obtain information about work demands.

Objective

To correlate upper limb muscle strength with fatigue resistance, work ability and dysfunction in a sample of workers from a university hospital.

Methods

Shoulder and elbow strength were assessed by Biodex System 4™, hand grip by JAMAR™, fatigue resistance by Functional Impairment test Hand/Neck/Shoulder/Arm (FIT-HaNSA), the ability to work by the Work Ability Index and upper limb dysfunction by QUICK-DASH-Br. The Brazilian version of the Pain Catastrophising Scale (B-PCS) was applied in order to analyse the catastrophic profile of the sample. The correlations were analysed by Spearman's Correlation Coefficient (rho)($p < 0.05$).

Results

27 workers presented with chronic pain of low intensity, were classified as active and underwent predominantly dynamic work. Muscle strength of abduction (0.49), adduction (0.40), internal rotation (0.44), elbow flexion (0.38) and hand grip (0.68) had a direct correlation with FIT-HaNSA. Only hand grip (-0.52) showed an inverse correlation with upper limb dysfunction. Muscle strength was not correlated with work ability or pain catastrophising.

Conclusion

The results suggested that increasing muscle strength may improve fatigue resistance. Also, improving hand grip strength could decrease upper limb dysfunction. In contrast to previous findings, muscle strength was not related to the ability to work or to pain catastrophising, because these factors are not only influenced by physical function, but also by psychosocial functioning.

1. Introduction

The upper extremity is related to the functional capacity to perform activities of daily living (ADLs), self-care tasks and sports (Soyer et al., 2016). When a person experiences pain and reduced mobility in this segment, functional skills, work performance and quality of life are negatively affected (Schunid et al., 2003).

Physical demands involving repetitive work, lack of muscle recovery, precision of movements and static postures are risk factors for the development of upper limb disorders (Nordander et al., 2009; Sundstrup et al., 2014; Ricco and Signorelli, 2017; Subramaniam et al., 2018). In particular, when associated with psychosocial factors, musculoskeletal disorders in the upper limbs generate high costs, long-term sickness absence and decreased productivity in many economic sectors (Lomond and Coté, 2009; Nordander et al., 2009; Eerd et al., 2016).

Since there is a substantial prevalence (36.8%) for complaints in the upper limbs, it is useful to obtain accurate information about work demands related to this segment (Jacobs et al., 2017). Thus, rehabilitation or prevention programs, ergonomic assessment and education strategies must be considered (Williams and Westmorland, 1994).

A careful musculoskeletal assessment should involve the analysis of all variables associated with the individual's health, such as the level of activity and function, characteristics of symptoms and level of strength to perform daily activities and work (Skirven, et al., 2011).

Muscle strength is the greatest predictor of function, mobility and independence (Roshanravan et al., 2016). An instrument used for this measurement is the dynamometer, which can be either isometric or isokinetic. Isokinetic evaluation analyses strength, power, work, fatigue percentage and muscle performance, and classifies these data as normal or altered. Thus, it allows the evaluation of the effectiveness of a treatment, dictates the rehabilitation objectives and establishes normative values of strength (Forthomme et al., 2002; Edouard et al., 2013; Adsuar et al., 2013; Amaral et al., 2014).

In addition to strength, fatigue resistance is another indicator of functionality and physical capacity. Work demand is an important ability to be analysed, considering that fatigue is a complaint frequently reported among workers. In this context, it can be defined as an imbalance between work demands and the worker's ability to perform a task. It is associated with a decrease in motor performance, speed and range of motion, and may be caused by repetition of a single activity for prolonged periods. Long-term fatigue increases the risk of incapacity for work and impairs the ability to maintain a satisfactory level of production (Yung and Wells, 2016; Sundstrup et al., 2016; Subramaniam et al., 2018).

To gain a better understanding of the variables involved in workers' musculoskeletal complaints, the aim of this study was to analyse the correlations between the muscle strength of the shoulder, elbow and hand with fatigue resistance, work ability and upper limb dysfunction in a sample of workers at a university hospital.

2. Method

This was a cross-sectional observational study which was approved by the local Research Ethics Committee (No. 2,724,782, CAAE 89138818.1.0000.5440) in accordance with the 1964 Helsinki Declaration and its subsequent amendments. All participants signed an informed consent form before participating in the study.

Sample The sample size calculation was performed with alpha 0.05, power 0.8 and an effect size of 10%, and identified 25 workers that were selected from different sectors at a tertiary-level university hospital. The included participants were individuals of both genders, aged between 25 and 60 years, who had pain or discomfort in the upper limb over the previous 12 months, which may have been unilateral or bilateral, and who predominantly used the upper limbs for work. We excluded people who had recent surgery or trauma and were unable to perform the proposed tests for physical or cognitive reasons.
OutcomesNumerical Pain Rating Scale (NPRS)

Using an 11-point scale ranging from zero (no pain) to ten (worst pain ever), participants were instructed to choose the numerical value that best represented their pain intensity at that moment, and a rating was made as follows: 0 (zero) - no pain, from 01 to 03 - mild pain, from 04 to 06 - moderate pain and from 07 to 10 - severe pain (Hartrick et al., 2003).

Nordic Musculoskeletal Questionnaire This was used to define the location and chronicity of symptoms. It consisted of a body map divided into 09 segments: neck, shoulders, upper back, elbows, wrists/hands, lower back, hips/thighs, knees and ankles/feet, and presented four questions with binary responses ("Yes/no") for each segment (Pinheiro, 2002). *International Physical Activity Questionnaire (IPAQ) – Short Version*

This instrument was applied in order to estimate the weekly time spent in physical activities carried out in a normal week, taking into account walking activities, activities with moderate and vigorous intensity that had a minimum duration of 10 continuous minutes, in addition to the time spent in the sitting position. The participants were characterised as very active, active or irregularly active and sedentary (Matsudo et al., 2001).

Quick-DASH-Br

This questionnaire was used to define the upper limb dysfunction level. It was composed of 11 items, taken from the DASH questionnaire of 30 items, in order to assess the symptoms, and physical and social function related to complaints in the upper limb. Each item was scored on a scale from 01 to 05 points, where 01 indicated "no difficulty" and 05 "extreme difficulty", with a final score ranging from 0 to 100 and the maximum score indicating greater dysfunction in the upper limb (Beaton et al., 2005; Da Silva et al., 2020).

Work Ability Index

This instrument was used to assess, through the worker's self-report, the participants' perception of working conditions and physical, mental and social capacity that may be related to their complaints. The index contained 10 questions divided into seven domains and the results provided a measure of work ability, which ranged from 07 to 49 points, and classified the ability as low (07 to 27), moderate (28 to 36), good (37 to 43) or excellent (44 to 49) (Martinez et al., 2009).

Pain Catastrophising Scale (B-PCS) This scale was used to assess the degree of pain catastrophising. The scale contained 13 items, in which the participant had to indicate the degree to which he/she presented any thought or feeling described, in a 05-point graduation: Minimum (0), Light (1), Moderate (2), Intense (3) or Very Intense (4). The total score was calculated by the sum of all items, ranging from 0 to 52, indicating the catastrophising level as high (> 30) or low (≤ 30) (Sullivan, 2009; Mosegaard et al., 2020). *Isokinetic and Isometric Dynamometer* Muscle strength was assessed using the Biodex System 4 Pro™ isokinetic dynamometer following all the calibration and use recommendations proposed by the manufacturer in the manual. The force variable used was the mean torque peak, at a speed of 60º/sec, as recommended for the evaluation of orthopaedic complaints (Prentice and Voight, 2003). The participant's position was based on the guidance material provided by the BiodexÔ system. The movements evaluated were abduction/adduction of the shoulder in the scapular plane, based on the angle proposed by Kapandji (2000), positioning the shoulder at 30º anterior to the frontal plane (Fig 01.), internal/external rotation of the shoulder (Fig 02.) and elbow flexion and extension (Fig 03).

Hand grip strength was assessed by a JAMARÔ isometric dynamometer which is an instrument recommended by the American Society of Therapists of Hand (ASTH) (Peolssonet al., 2001). The participant was placed seated in a chair without an armrest, their feet flat on the floor, shoulder adducted with neutral rotation, elbow flexed at 90° and the forearm in a neutral position (Fig 04.). The JAMARÔ handle was attached in the second position (Shiratori et al., 2014) which allows a balanced activation of the intrinsic and extrinsic flexors of the fingers (Skirven et.al, 2011). Three repetitions were performed on each side to calculate mean hand grip strength.

Fatigue resistance A JobSim™ System prototype was developed and used to perform the fatigue resistance test "Functional Impairment Test-Hand, and Neck/Shoulder/Arm" (FIT-HaNSA). It is a three-task test that represents upper limb gross motor functions, such as reaching and holding objects at different heights and work sustained above the head (MACDERMID et al., 2007) (Fig 05.). The test consisted of performing two unimanual and one bimanual task, developed in the following steps: *Task 1) Waist-up:* One shelf was placed at waist level and the other 25 cm above it. Three 01kg containers were placed on the lowest shelf. The participant was instructed to move the three containers from one shelf to another, at a speed of 60 beats/minute, controlled by a metronome.

Task 2) Eye-Down: One shelf was placed at eye level and the other 25 cm below it. The participant was again instructed to move the three containers from one shelf to another at the same speed.

Task 3) Overhead-Work: A board containing screws was attached perpendicularly to the shelf at eye level. The participants were instructed to keep both arms raised and use them to screw and unscrew the screws in a predetermined sequence: the screw that was on level 01 (top) must be moved to level 02 (middle); the screw from level 03 (lower) to level 01 and the screw from level 02 to level 03.

Each task was performed only once for a maximum of 300 seconds or when the volunteer interrupted the test due to pain, fatigue or disability. The rest between one task and another was established by the time taken to adjust the shelf for the subsequent task (MacDermid et al., 2007). To analyse the correlations, the average time of the three tasks was calculated.

Procedure

The evaluation was carried out in a single day and applied by the same physiotherapist. If the participant had bilateral complaints or pain in more than one joint of the upper limb, the site and member of highest pain intensity was defined as the symptomatic member/site measured by NPRS. Before starting the tests, instrument familiarisation and randomisation of muscle strength and fatigue resistance tests was performed. The tests were preceded by a 05-minute warm up on the cycle ergometer and as a rest criterion, a socio-demographic form and the questionnaires were applied.

Statistical Analysis

The correlations were analysed by Spearman's Correlation Coefficient (*rho*) which measures the degree of linear association between two variables. This coefficient is a measure used in non-parametric samples, for two ordinal variables or when one variable is continuous and the other is categorical or non-normal (Di Fabio, 2013), and can range from -1 to 1. Values close to -1 indicate the maximum inverse correlation and values close to 1 indicate the maximum direct correlation (De Vet et al. 2011).

The results were based on Di Fabio (2013), who considers 0.75-1 a strong correlation, 0.50-0.74 moderate, 0.49-0.25 weak and insignificant or absent between 0.24-0. Conceptually, when one variable increases or decreases, either directly or inversely, the other changes in the same proportion. The level of significance established was $p \leq 0.05$, and the software used was SPSS version 20.0™.

3. Results

Twenty-six out of twenty-seven participants were right-handed and only one was left-handed, with handedness being assessed by *The Lateral Preference Inventory* (Marim et al., 2011). 59.25% reported pain in the dominant limb and 40.74% in the non-dominant limb. All of the participants predominantly used the upper limbs in their functions but with different levels of effort. 62.96% performed dynamic work, with a high level of physical effort, including lifting/shifting loads; 11.11% performed dynamic work but without lifting/shifting loads; and 25.92% had static work characteristics with a low level of physical effort, and maintaining the same position for prolonged periods. The selection of participants and work sectors are described in the flowchart in Fig. 06.

There was a similar proportion of men and women aged between 26 and 59 years. By IPAQ questionnaire, 18.51% were classified as very active, 37.03% as active, 37.03% as irregularly active and 7.40% as sedentary. Data that characterise the sample are summarised in table 01.

Table 01 – Sample characterisation

Gender (Men – Women)	11–16
Age	46.22 ± 8.90
BMI (%)	Normal 33.33% Overweight 22.22% Obese 44.44%
Comorbidities	Presented 37.00% Didn't have 62.90%
Smokers	None

Using the Nordic questionnaire, it was found that all participants had symptoms of the upper limbs for at least 12 months, with a predominance of symptoms in the shoulder joint (55.55%). In addition, 88.88% reported pain in other segments during the same period. 70.37% still complained of the same symptoms in the upper limbs in the last 07 days.

Pain intensity was classified as mild and the Quick-DASH-Br showed that workers had a low level of upper limb dysfunction. A deficit of 50% in fatigue resistance was found in the symptomatic limb when comparing the expected total time with the total time spent to perform the three tasks. These values are presented in table 02.

Table 02 - Mean values of pail intensity, upper limb dysfunction and fatigue resistance

NPRS	3.03 ± 2.29
Quick-DASH-Br	30.30 ± 21.30
FIT-HaNSA (average time for the three tasks)	149.40 ± 62.84

± Standard Deviation

NPRS – Numerical Pain Rating Scale

FIT-HaNSA – average time in seconds

In relation to the work ability index, 7.40% were classified as low ability, 44.44% as moderate, 37.03% as good ability and 11.11% excellent. Still on work issues, 55.55% of the participants claimed long-term sickness absence due to musculoskeletal problems.

In 17 participants, the Pain Catastrophising Scale (B-PCS) was applied, which showed that 35.29% of the participants had a high level of catastrophising and 64.70% had a low level.

Muscle strength showed a significant correlation with FIT-HaNSA, except in regard to external shoulder rotation and elbow extension, with direct and weak correlations for abduction, adduction, internal rotation and elbow flexion movements and a moderate correlation for hand grip. Hand grip strength also showed a moderate inverse correlation with upper limb dysfunction. The correlations between the other proposed constructs were not significant. Table 03 shows the numbers of correlations obtained and the respective statistical significance level, with a 95% confidence interval ($p < 0.05$). Graphic 01 shows the average strength values obtained for women and men.

Table 03 - Values of correlation of muscle strength with fatigue resistance test and self-report questionnaires

Average Torque Peak	**Quick-*DASH*-Br**	**Work Ability Index**	**FIT-HaNSA**	**B-PCS**
Shoulder				
Abduction	-0.34*	0.19*	0.49*	-0.10*
	0.08**	0.34**	0.01**	0.69**
Adduction	-0.18*	-0.01*	0.40*	0.00*
Internal Rotation	0.36**	0.92**	0.03**	0.98**
	-0.32*	0.10*	0.44*	-0.06*
	0.09**	0.58**	0.02**	0.81**
External Rotation	-0.36*	0.14*	0.33*	-0.26*
	0.06**	0.48**	0.08**	0.30**
Elbow				
Flexion	-0.35-*	0.20*	0.38*	-0.19*
	0.07**	0.31**	0.05**	0.45**
Extension	-0.05*	-0.18*	0.24*	0.16*
	0.80**	0.36**	0.22**	0.54**
Hand grip	-0.52*	0.31*	0.68*	0.12*
	0.00**	0.10**	0.00**	0.96**

* Spearman correlation (*rho*)

**Significance Level ($p \leq 0.05$)

4. Discussion

Although mostly active, almost half of the sample were obese according to their BMI. Studies strongly suggest that pain and obesity are significantly correlated and this relationship can be measured by factors such as structural changes, inflammatory chemical mediators and mood and sleep disorders, all of which are potential markers of functional and psychological complications in chronic pain (Haukka et al., 2012; Arranz et al., 2014; Okifuji and Hare, 2015). A longitudinal study that followed kitchen workers showed that obesity was a risk factor for generalised pain (Haukka et al., 2012). In addition, pain in different places increases the risk of sick leave and disability (Haukka et al., 2012; Mather et al. 2019). These studies agree with our data sample, since more than half reported long-term sickness absence due to musculoskeletal complaints and complained of pain in other segments besides the upper limbs.

Fatigue resistance was impaired in this sample. Despite the weak magnitude of correlation, our data showed a significant and direct interaction between fatigue resistance and muscle strength for all moviments, except for the external shoulder rotation and elbow extension, suggesting that muscle strength and fatigue resistance change in the same direction. Sundstrup and collaborators (2014) outlined that musculoskeletal pain aggravates the development of muscle fatigue. They observed that resistance training significantly improved muscle strength and reduced pain and disability, suggesting an interaction between fatigue resistance and strength in a sample of workers complaining of chronic pain in the upper limbs.

It is known that hand grip strength is correlated with different functional disorders of the upper limbs, such as rheumatoid arthritis, carpal tunnel syndrome, lateral epicondylalgia, stroke, traumatic injuries and neuromuscular diseases, and it is also strongly related to general health status (Novaes et al., 2009; HORSLEY, et al., 2016). Our study agrees with these findings, as we observed a significant and moderate inverse correlation between hand grip strength and upper limb dysfunction, showing that the dysfunction decreased when the hand grip strength increased.

Even with a low level of upper limb dysfunction and a satisfactory level of physical activity, these characteristics were not enough for most participants to perceive that they had an excellent work ability, since the ability to work was considered moderate. There was no correlation between muscle strength and ability to work. This can be explained by the fact that the ability to work is not only influenced by physical function, but also by psychological, cognitive and social functioning. These factors are, in turn, affected by pain, and the association of these variables negatively interferes with the ability to work (Hengstebeck et al., 2017).

Regarding psychosocial issues, only 35.29% recorded a high catastrophising score, and this score did not show any correlation with the physical and functional parameters evaluated. This finding does not agree with the results of previous studies that found an association between these variables in other populations. For example, Özkan and collaborators (2017) proposed that psychological factors are strong predictors of upper limb dysfunction and in their study they found a significant interaction between catastrophising symptoms and dysfunction of the upper limb in patients who underwent hand surgery. High levels of catastrophising pain also demonstrated a negative influence on physical function in the pre and postoperative period of knee arthroplasty (Birch et al. 2019) and the level of satisfaction after surgical release from carpal tunnel syndrome (Mosegaard et al., 2020), and increased disability and decreased the quality of life in patients with diabetic neuropathy (Geelen et al. 2017). However, the workers of the present study were demonstrated to be active and had a predominantly dynamic work characteristic, which may have contributed to lower levels of catastrophising. According to Elfving et al. (2007) and Geelen et al. (2017), low levels of physical activity are associated with higher levels of catastrophising.

Study Limitations

The methodology used does not allow us to establish a causal factor or risk factors, so the findings are only suggestive of interactions between the constructs. In addition, the sample size did not allow the analysis of subgroups that considered the individuality of each worker profile in terms of magnitude and characteristics of effort.

There were also no detailed analyses on the ergonomic conditions of the work environment nor on the social and psychological relationships of the workers, which would be relevant considering that the ability to work could be influenced by these aspects.

5. Conclusion

The correlation between muscle strength and fatigue resistance suggests that increasing muscle strength may improve fatigue resistance in workers with upper limb complaints.

Improving hand grip strength can be important to decrease upper limb dysfunction in workers since these variables showed an inverse correlation.

In contrast to previous findings, muscle strength was not related to the ability to work or to pain catastrophising, and it is likely that this is because these factors are not only influenced by physical functioning, but also by psychological, cognitive and social functioning.

These findings may be useful for future analyses of similar worker profiles, and may have particular relevance for the development of interventions aimed at preventing the development of musculoskeletal complaints in the upper limbs related to work.

6. Declarations

• Ethics approval and consent to participate

This study was approved by the University of São Paulo of Ribeirão Preto’ Research Ethics Committee (No. 2,724,782, CAAE 89138818.1.0000.5440) in accordance with the 1964 Helsinki Declaration and its subsequent amendments. All participants signed an informed consent form before participating in the study.

• Consent for publication

Not applicable

• Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

• Competing Interest

The authors declare that they have no competing interests.

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7. References

1. Adsuar JC, et al. **Applicability and Test-Retest Reliability of Isokinetic Shoulder Abduction and Adduction in Women Fibromyalgia Patients**. Archives of Physical Medicine and Rehabilitation 2013; (94): 444–450.
2. Amaral GM, et al. Muscular performance Characterization in athletes: a new perspective on isokinetic variables. Braz J Phys Ther. 2014;18(6):521–9.
3. Arranz LI, Rafecas M, Alegre C. Effects of Obesity on Function and Quality of life in Chronic Pain Conditions. Curr Rheumatol Rep. 2014;16(1):390.
4. Beaton DE, Wright JG, Katz JN. Development of the QuickDASH: comparison of three item-reduction approaches. J Bone Joint Surg Am. 2005;87(5):1038–46.
5. Da Silva NC, et al. **Reliability, validity and responsiveness of Brazilian version of QuickDASH**. Musculoskeletal Science and Practice. 2020.
6. De Vet HCW, et al. Measurements in Medicine. Cambridge: Cambridge University Press; 2011.
7. Di Fabio RP. **Essentials of rehabilitation research**. **A statistical guide to clinical practice**. David Plus; 2013. p. 229.
8. Edouard P, et al. **Reliability of shoulder rotators isokinetic strength imbalance measured using the Biodex dynamometer**. Journal of Science and Medicine in Sport 2013; 162–165.

9. Eerd DV. **Effectiveness of workplace interventions in the prevention of upper extremity musculoskeletal disorders and symptoms: an update of the evidence**. Occup Environ Med 2016; (73): 62–70.
10. Elfving B, Andersson T, Grooten W. Low levels of physical activity in back pain patients are associated with high levels of fear-avoidance beliefs and pain catastrophizing. Physiotherapy Research International. 2007;12(1):14–24.
11. Forthomme B, et al. **Isokinetic assessment of the forearm and wrist muscles**. **Isokinetics and Exercise Science** 2002; 10(3): 121–128.
12. Geelen CC, et al. **Perceived Physical Activity Decline as a Mediator in the Relationship Between Pain Catastrophizing, Disability, and Quality of Life in Patients with Painful Diabetic Neuropathy**. Pain Pract 2017; (3): 320–328.
13. Haukka E. **et** al. Pain in Multiple Sites and Sickness Absence Trajectories: A Prospective Study Among Finns. Pain. 2012;154(2):306–12.
14. Horsley I, et al. Do changes in hand grip strength correlate with shoulder rotator cuff function? Shoulder Elbow. 2016;8(2):124–9.
15. Hengstebeck E, et al. **Chronic pain disrupts ability to work by interfering with social function: a cross-sectional study**. Scandinavian Journal of Pain 2017; (17): 397–402.
16. Jacobs NW, et al. **Validity and Reliability of the Upper Extremity Work Demands Scale**. J Occup Rehabil 2017; (27): 520–529.
17. Kapandji AI. **Fisiologia Articular – Membros Superiores**. 5ª Ed. Rio de Janeiro: Guanabara Koogan; 2000.
18. Lomond K, Cote J. **Shoulder functional assessments in persons with chronic neck/shoulder pain and healthy subjects: Reliability and effects of movement repetition**. Work 2009; (38): 169–180.
19. Macdermid JC, et al. Validation of a new test that assesses functional performance of the upper extremity and neck (FIT-HaNSA) in patients with shoulder pathology. BMC Musculoskelet Disord. 2007;42(8):1–10.
20. Marim EA, Lafasse R, Okazaki VHA. Inventário de preferência lateral global (IPLAG). Brazilian Journal of Motor Behavior. 2011;6(3):14–23.
21. Martinez MC, Latorre MRDO, Fischer FM. Validade e confiabilidade da versão brasileira do Índice de Capacidade para o Trabalho. Rev Saúde Pública. 2009;43(3):525–32.
22. Mather L, et al. Health, work and demographic factors associated with a lower risk of work disability and unemployment in employees with lower back, neck and shoulder pain. BMC Musculoskelet Disord. 2019;622(20):2–10.
23. Matsudo S, et al. Questionario internacional de atividade fisica (IPAQ): Estudo de validade e reprodutibilidade no Brasil. Atividade Física e Saúde. 2001;6(2):1–14.
24. Mosegaard SB, Stilling M, Hansen TB. Higher preoperative pain catastrophizing increases the risk of low patient reported satisfaction after carpal tunnel release: a prospective study. BMC Musculoskelet

Disord. 2020;21:42.

25. Nordander C, et al. Risk of musculoskeletal disorders among females and males in repetitive/constrained work. Ergonomics. 2009;52(10):1226–39.
26. Novaes RD, et al. Equações de referência para a predição da força de preensão manual em brasileiros de meia idade e idosos. Fisioterapia e Pesquisa. 2009;16(3):217–22.
27. Okifuji A, Hare BD. The association between chronic pain and obesity. Journal of Pain Research. 2015;8:399–408.
28. Özkan S, et al. Associations Between Pain Catastrophizing and Cognitive Fusion in Relation to Pain and Upper Extremity Function Among Hand and Upper Extremity Surgery Patients. Ann Behav Med. 2017;51(4):547–54.
29. Peolsson A, Hedlund R, Oberg B. Intra- and inter-tester reliability and reference values for Hand strength. J Rehab Med. 2001;33:36–41.
30. Pinheiro A, et al. Validação do Questionário Nórdico de Sintomas Osteomusculares como medida de morbidade. Rev Saúde Pública. 2002;36(3):307–12.
31. Prentice WE, Voight ML. Técnicas em Reabilitação Musculoesquelética. 4ed. São Paulo: Artmed; 2003.
32. Ricco M, Signorelli C. Personal and occupational risk factors for carpal tunnel syndrome in meat processing industry workers in northern Italy. Med Pr. 2017;68(2):199–209.
33. Roshanaravan B. Association of Muscle Endurance, Fatigability, and Strength With Functional Limitation and Mortality in the Health Aging and Body Composition Study. J Gerontol A Biol Sci Med Sci. 2016;00(00):1–8.
34. Schunid FA, Mouraux D, Robert C. **Functional and outcome evaluation of the hand and wrist**. Hand Clin 2003; (19): 361–369.
35. Shiratori AP, et al. Protocolos de avaliação da força de preensão manual em indivíduos com artrite reumatoide: uma revisão sistemática. Revista Brasileira de Reumatologia. 2014;54(2):140–7.
36. Soyer K, et al. The importance of rehabilitation concerning upper extremity amputees: A Systematic Review. Pak J Med Sci. 2016;32(5):1312–9.
37. Skirven TM, et al. **Rehabilitation of the Hand and Upper Extremity**. 6th ed. Expert Consult; 2011. p. 6–12.
38. Subramaniam S, Murugesan S, Jayaraman S. Assessment of shoulder and low back muscle activity of male kitchen workers using surface electromyography. Int J Occup Med Environ Health. 2018;31(1):81–90.
39. Sullivan MJ. The pain catastrophizing scale - user manual. 5th ed. Montreal: McGill University; 2009.
40. Sundstrup E, et al. **Effect of Two Contrasting Interventions on Upper Limb Chronic Pain and Disability: A Randomized Controlled Trial**. Pain Physician 2014; (17): 145–154.
41. Williams R, Westmorland M. **Occupational Cumulative Trauma Disorders of the Upper Extremity**. Am J Occup Ther. 1994.

42. Yung M, Wells RP. **Sensitivity, Reliability, and the Effects of Diurnal Variation on a Test Battery of Field Usable Upper Limb Fatigue Measures**. Ergonomics 2016: 1–51.

Figures

Figure 1

A,B,C. Shoulder in the scapular plane to assess abduction and adduction

Figure 2

A,B. Shoulder position to assess internal and external rotation

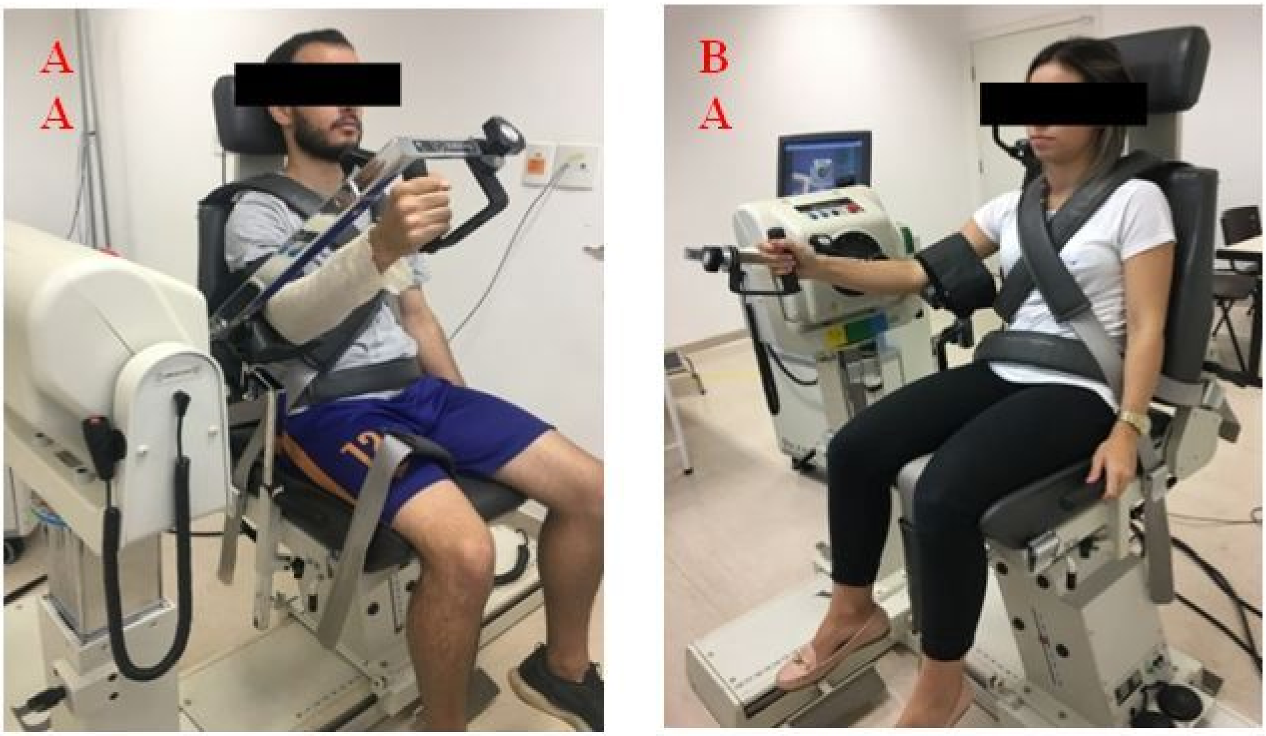


Figure 3

A,B. Elbow position to assess Flexion and Extension

Figure 4

Position to assess Handgrip

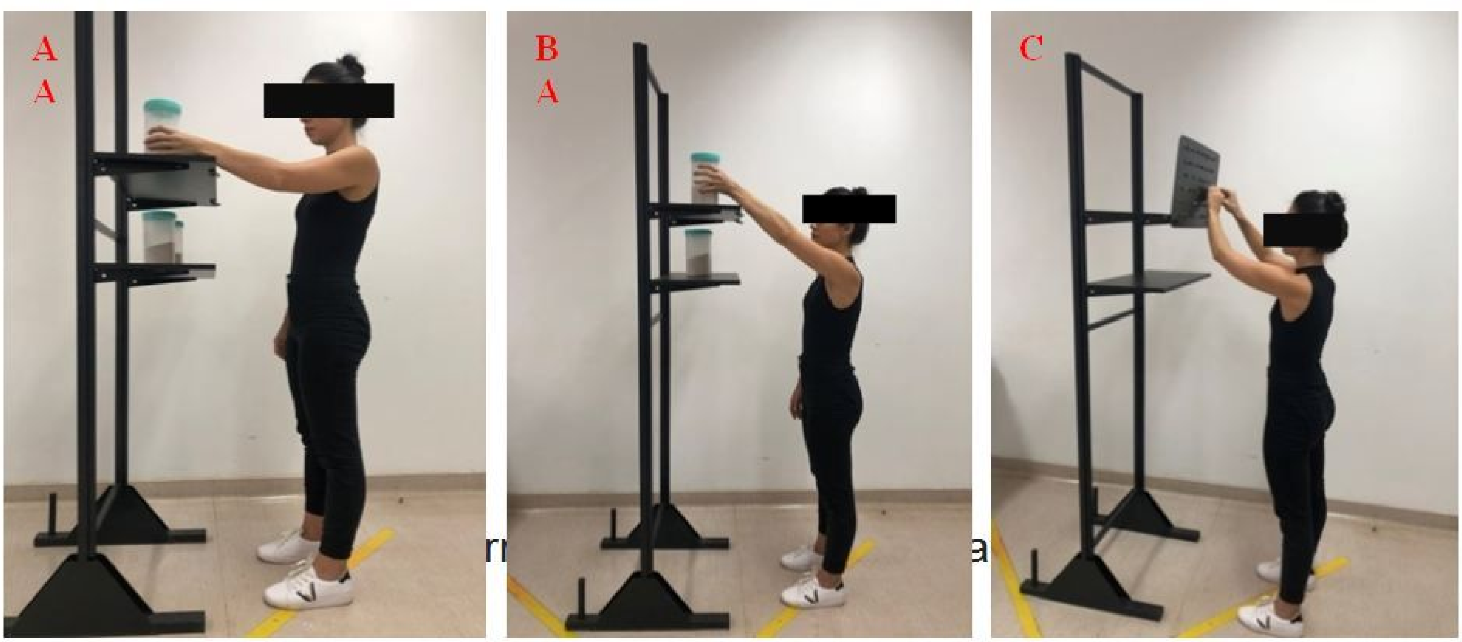


Figure 5

Fig 05 A,B,C. FIT-HaNSA Tasks 1, 2 and 3

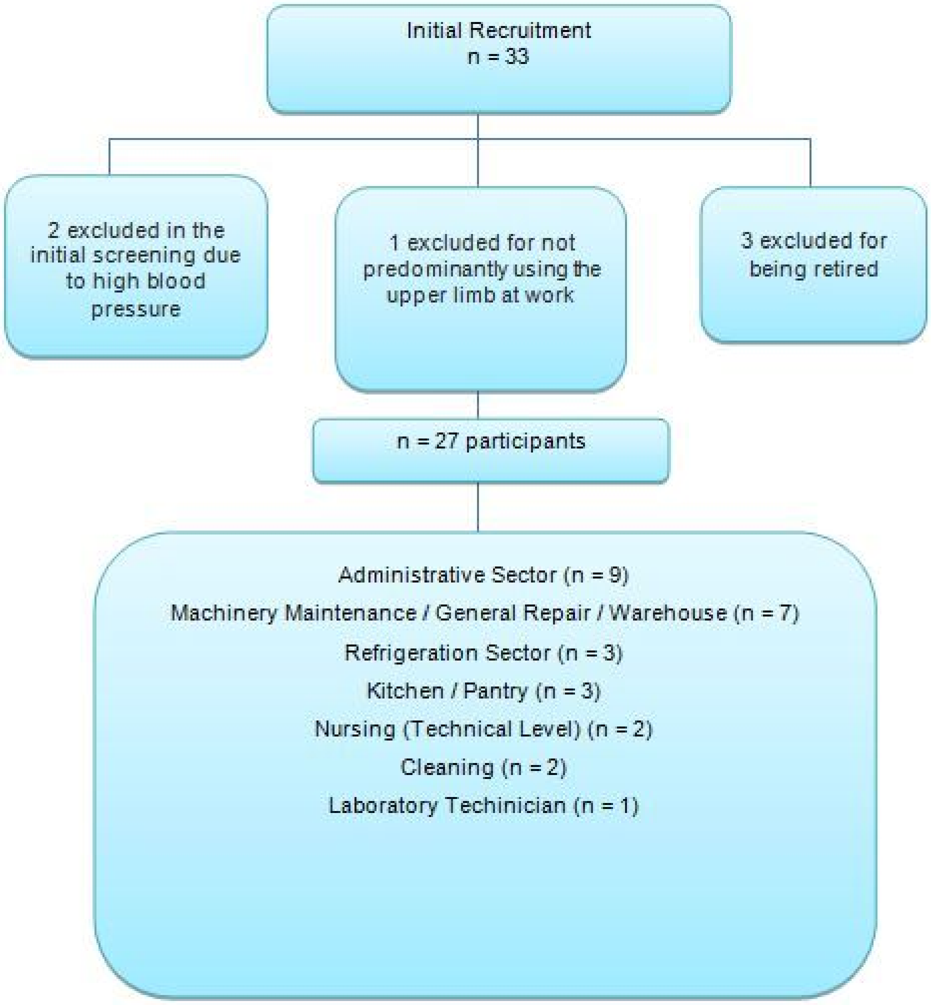
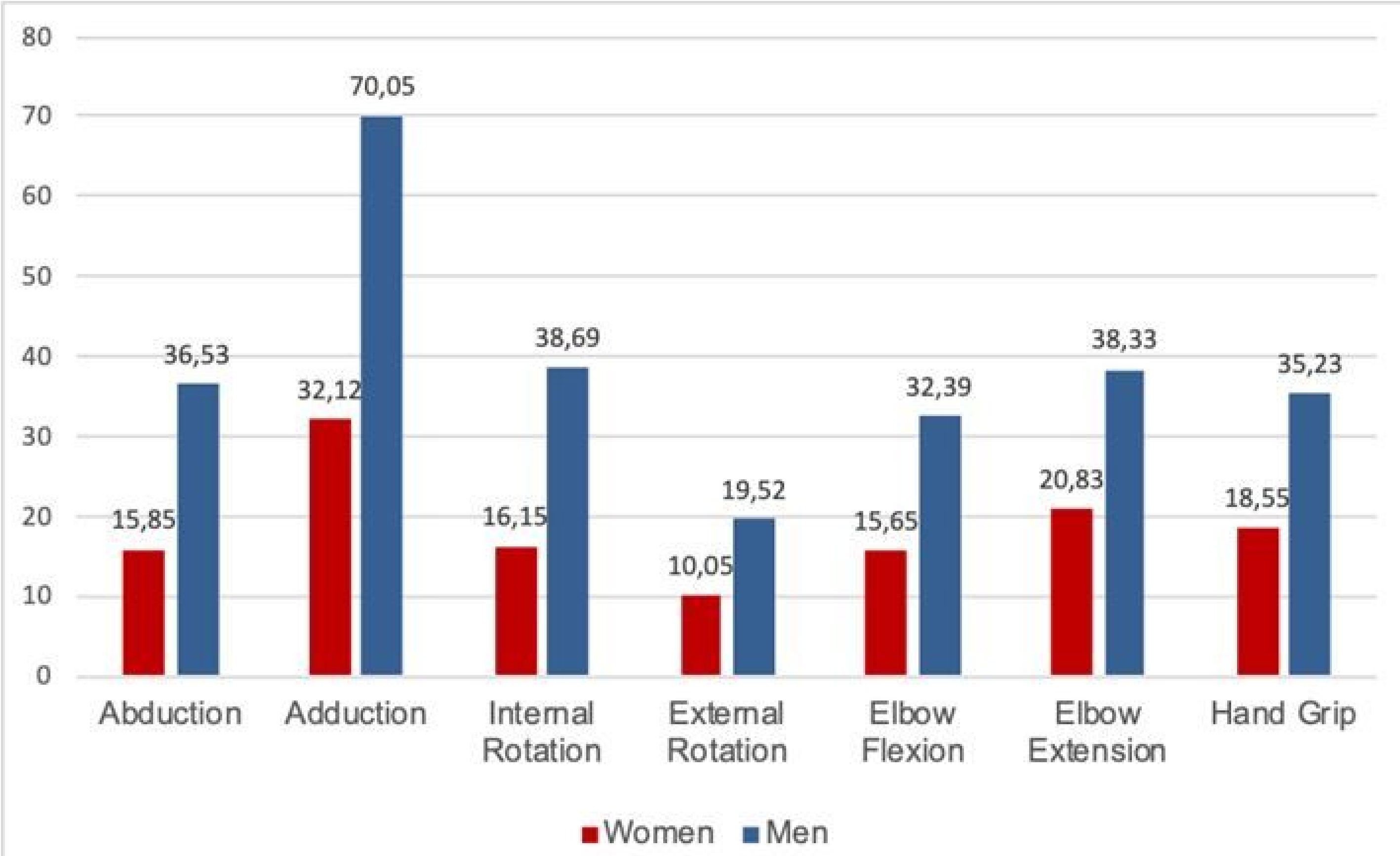


Figure 6

Participant selection and work sectors



Elbow and Shoulder strength = Newtons.metre (Nm)
Handgrip strength = kilograms.force (kgf)

Figure 7

Values of strength for women and men