Isokinetic Assessment of Wrist Muscles Performance among Egyptian Physical Therapy Students with Chronic Non-Specific Neck Pain

BY

Mohamed Mahmoud Refaey Ahmed Salama

B.SC. in Physical Therapy (2018) KAFR EL SHEIKH University

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Faculty of physical therapy
Cairo University

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Supervisors

Prof. Enas Fawzy Youssef
Professor and Head of Physical Therapy Department
of Musculoskeletal Disorders and Its Surgery
Faculty of Physical Therapy
Cairo University

Prof. Anees Saleh Gheit
Professor and Head of Biomechanics Department
Faculty of Physical Therapy
Kafr El sheikh University

Dr. Aya Abdelhamied Mohamed Khalil

Lecturer of Biomechanics
Department of Biomechanics
Faculty of Physical Therapy
Cairo University

Chapter I

Introduction

Non-specific neck pain is a condition characterized by a reduction in range of motion and the presence of neck pain, without any identifiable pathology or abnormal anatomical structure **(Zafar et al., 2021)**. Non-specific neck pain can be identified by several signs and symptoms including muscle spasms, trigger points, limited range of motion, and headaches. Muscle spasms are characterized by rapid, strong, and involuntary contractions of the muscles, while trigger points typically cause pain in the center or one side of the back of the neck. Individuals with non-specific neck pain may also experience headaches and a reduced range of motion in the neck **(Cohen, 2015)**.

Non-specific neck pain is associated with risk factors such as age, past musculoskeletal pain, gender, occupation, headaches, mental health issues, smoking, unsatisfactory job, dissatisfaction, difficult work postures, poor physical work environment, and inadequate physical ability **(Jahre et al., 2020)**. Various physical and biomechanical factors have been linked to functional limitations in patients experiencing persistent neck pain **(Côté et al., 2016)**. For example, a strong correlation was found between the level of functional disability and the degree of forward head posture in individuals with neck pain **(Kim and Kim, 2016)**, despite being recognized as a leading contributor to functional impairment in individuals with neck pain, inadequate control of the axio-scapular muscles persists as a major issue **(Wannaprom et al., 2021)**.

Nevertheless, there is another opinion that says there is no association between forward neck posture and pain in adolescents **(Mahmoud et al., 2019)**. Neck flexion while using a smartphone device (also known as "text neck") is also not associated with pain in adolescents **(Damasceno et al., 2018)**.

In Egypt, a study conducted among medical students showed that 81.1% of participants experienced neck pain and/or low back pain. This pain was primarily attributed to long hours of studying and reading, especially in the clinical years. Participants also reported ergonomic problems and poor psychological studying environments **(Alian et al., 2021)**. The study found gender differences in pain intensity and prevalence, with males reporting a higher prevalence of lifetime lower back pain **(AlShayhan & Saadeddin, 2018)** while females had a higher prevalence of neck and shoulder discomfort, as well as pain or numbness in their wrists **(Mustafaoglu et al., 2021).**

In **2022, Ortego et al** hypothesized that there is a notable association between neck problems and upper limb disabilities, although the mechanisms underlying this correlation are not yet well understood. Potential factors contributing to this association include deconditioning, peripheral nerve injuries, and mechanical stress.

The upper limb is mechanically connected to the neck and shoulder girdle via the skeletal and muscular systems. Mechanical loading of the upper limb may directly cause discomfort in the neck by increasing stress on the ligamentous and articular structures, or by inducing muscle spasm as a protective response **(Kumar et al., 2018).**

Non-specific neck pain is significantly associated with impaired performance of the muscles in the upper limb, leading to upper limb disability **(Alreni et al., 2015)**. Upper limb disability (ULD) is a term used to describe the limitations someone experiences while engaging in physical activities related to the upper limb, such as carrying, lifting, and overhead movements. Adequate upper limb strength, endurance, and proprioception are essential for performing many job-related tasks effectively **(Gillen & Nilsen, 2020)**. There was a study has shown that neck pain can lead to imbalances in muscle function, instability in joints, and reduced proprioception in the upper limb **(Tabbert et al., 2022)**.

The connection between the neck and the upper limb can be established through various systems, including the skeletal, muscular, and neurological systems **(Alreni et al., 2017)**. Muscle fatigue is a significant impairment within these systems, which refers to the gradual decline in a muscle's capacity to generate maximal force. Fatigue can occur due to intensive and repetitive maximal contractions or by repeating submaximal contractions over an extended period **(Cheng et al., 2016)**. Neck muscle fatigue and pain can affect the ability to perceive movement and position of the upper limb **(Zabihhosseinian et al.,2015).**

The gold standard for measuring wrist muscle performance is the isokinetic dynamometer. It is preferred because it allows for a fixed velocity and variable resistance that adapts to the user throughout the full range of motion **(Muñoz-Bermejo et al., 2019)**. The isokinetic device is a tool that can aid in the evaluation of muscle function by quantifying muscle strength, torque, and endurance **(Marklund, 2019)**. Isokinetic exercise has been a commonly used concept in the evaluation and rehabilitation of musculoskeletal function in limbs **(Mcgrath et al., 2016**).

Isokinetic dynamometer can also be used to measure the work fatigue index, which is the percentage change in performance from the beginning to the end of an endurance test. This index is a useful measure of muscle endurance and the ability to maintain performance over time **(Bosquet et al., 2016)**. Work fatigue index refers to the decline in output over multiple repetitions during an endurance test **(Gerodimos et al., 2017)**.

Although it is widely acknowledged that chronic non-specific neck pain is linked to hand disability as previously studied on dentists and ministry of health care stuff **(Fayez, 2014; Kahraman et al., 2017)**, there is still a gap in illustrating the effect of chronic non-specific neck pain on Egyptian physical therapy students' functional ability of wrist in the upper limb. However, the assessment of extensor / flexor wrist strength ratio has only recently gained attention. Furthermore, there is limited research investigating the strength control ratio that incorporates both concentric and eccentric muscle actions, and additional scientific evidence is needed to establish the relationship between chronic non-specific neck pain and upper limb disability. This study will be conducted to set new assessment and rehabilitation goals. This will subsequently be translated into home therapy program, contributing to decrease the burden of neck pain economically and on health care management.

Statements of the problem:

Does chronic non-specific neck pain affect peak torque of wrist extensor and flexor muscles /body weight among Egyptian physical therapy students?

Does chronic non-specific neck pain affect extensor / flexor wrist ratio among Egyptian physical therapy students?

Does chronic non-specific neck pain affect wrist extensor and flexor muscles endurance among Egyptian physical therapy students?

Purposes of the study:

To assess the effect of chronic non-specific neck pain on peak torque of wrist extensor and flexor muscles /body weight among Egyptian physical therapy students.

To assess the effect of chronic non-specific neck pain on extensor / flexor wrist ratio among Egyptian physical therapy students.

To assess the effect of chronic non-specific neck pain on wrist extensor and flexor muscles endurance among Egyptian physical therapy students.

Significance of the study:

Several studies have reported the neck region as the most common site of pain in college students, including medical students. Additionally, some adolescents have reported pain in their wrists and hands **(Alsalameh et al., 2019)**. Determinants of musculoskeletal pain include the amount of time spent sitting continuously, the frequency of breaks, head position while working at a desk, and level of physical activity **(Acaröz Candan et al., 2019)**

Neck discomfort is a significant burden that is often associated with disability and absenteeism from work **(Oliv et al., 2019)**. Experiencing pain in more than one site has been associated with decreased work quality and quantity, as it impairs upper limb performance and leads to upper limb disability **(Gane et al., 2018)**.

Non-specific neck pain has been shown to have an impact on hand function. **(Mahmoud et al., 2020)**. Non-specific neck pain has a significant correlation with impaired upper limb muscle performance, leading to upper limb disability **(Gurav & panhale, 2017)**.

Although it is widely acknowledged that chronic non-specific neck pain is linked to hand disability as previously studied on dentists and ministry of health care stuff **(Fayez, 2014; Kahraman et al., 2017)**, there is still a gap in illustrating the effect of chronic non-specific neck pain on Egyptian physical therapy students' functional ability of wrist in the upper limb. However, the assessment of extensor / flexor wrist strength ratio has only recently gained attention. Furthermore, there is limited research investigating the strength control ratio that incorporates both concentric and eccentric muscle actions, and additional scientific evidence is needed to establish the relationship between chronic non-specific neck pain and upper limb disability. This study will be conducted to set new assessment and rehabilitation goals. This will subsequently be translated into home therapy program, contributing to decrease the burden of neck pain economically and on health care management.

Delimitations:

- Egyptian physical therapy students with chronic non- specific neck pain from faculties of physical therapy with referral from orthopedic surgeons by diagnosis with non-specific neck pain.
- The duration of non-specific neck pain is more than 3 months without neurological manifestations.
- The smartphone application forward head posture will be used to measure craniovertebral angle (CVA) in a standing position **(Gallego-Izquierdo et al., 2020)**.
- Numerical Pain Rating Scale is used to assess pain intensity **(Sharma et al., 2017)**. Neck pain intensity on the numerical Pain Rating Scale will be between 3 to 8.
- Arabic version of the Neck Disability Index (NDI) is used to assess patients' self-reported neck pain-related disability **(Young et al., 2019)**. Neck pain-related disability on the Neck Disability Index will be between 5-14points (10 – 28%) mild disability and 15-24points (30-48%) moderate disability.

- Arabic version of the Fatigue Severity Scale is used to evaluate subject perceptions of hand function, activities of daily life, pain, and work performance **(Al-Sobayel et al., 2016)**.

- Patient's age ranges from 18 to 23 years.

- Body mass index for patients will not be less than 18.5 and not more than 29.5 **(Alasadi, 2018)**.

- Selected subjects will be assigned to two equal groups: the study group (GA) (chronic non-specific neck pain subjects) and the control group (GB) (without neck pain subjects).

Basic Assumption:

- All subjects will conduct and follow the instructions of the study.
- All subjects will exert their maximum effort during assessment.

Hypotheses:

There will be no significant effect of chronic non-specific neck pain on peak torque of wrist extensor muscles /body weight.

There will be no significant effect of chronic non-specific neck pain on peak torque of wrist flexor muscles /body weight.

There will be no significant effect of chronic non-specific neck pain on extensor / flexor wrist ratio.

There will be no significant effect of chronic non-specific neck pain on wrist extensor muscles endurance.

There will be no significant effect of chronic non-specific neck pain on wrist flexor muscles endurance.

Chapter II

Literature review

The wrist is the most important region in the upper limb as its role in daily activities like reaching, grasping, griping, and forming precise movements like writing and sewing. The wrist **is** made up by the distal radius, ulna, carpal bones, and metacarpal bases are only a few of the bones that constitute three joint areas the distal radioulnar (DRUJ), midcarpal, and carpometacarpal **(Regal et al., 2020)**.

Under normal conditions, the interosseous ligaments connecting the bones of the proximal carpal row insulate the midcarpal joint from each other and the radiocarpal joint from the distal radioulnar joint (DRUJ) by triangle fibrocartilaginous cartilage (TFCC) **(Gietzen et al., 2022).** The head of the ulna, the sigmoid notch area of the distal radius, the distal radioulnar joint capsule, and triangle fibrocartilaginous cartilage (TFCC) make up distal radioulnar joint (DRUJ). The distal radioulnar joint (DRUJ) and radiocarpal joint are normally separate joints **(Ng et al., 2017)**.

The overall wrist motion during ulnar deviation is mostly influenced by the radiocarpal joint and the midcarpal joint to a lesser extent. The arthrokinematics of extension and flexion are supported by the coordinated convex-on-concave rotations at the radiocarpal and midcarpal joints. When the wrist is fully extended, all the muscles that cross on the palmar side of the wrist and the palmar radiocarpal ligaments stretch, stabilizing the wrist by creating tension in these strained tissues (closed packed position of wrist) **(Magee, 2020)**.

As it is an ellipsoid-shaped synovial joint, the wrist can conduct flexion and extension as well as abduction and adduction. Although many muscles cross the wrist joint, only a small number of them are specifically used for wrist movement. These muscles are the extensor carpi radialis brevis (ECRB) and extensor carpi radialis longus (ECRL), which both contribute to wrist extension and radial deviation; extensor carpi ulnaris (ECU), which is responsible for wrist extension and ulnar deviation; flexor carpi radialis (FCR), which flexes and abducts (radial deviation) the wrist; and the extrinsic hand muscles, flexor digitorum superficialis (FDS) and extensor digitorum (ED), span the wrist and interphalangeal joints flexing and extending the digits **(Tortora & Derrickson, 2018)**.

Also, a complicated network of collagen fascicles created by the ligaments of the wrist perform a variety of tasks, including limiting joint displacement, directing motion, and maybe giving afferent brain feedback about the mechanical state of the joint **(Hall, 2022)**.

The neck and wrist are interconnected anatomically, and any dysfunction in one area can lead to compensations or problems in the other **(Fiebert, 2021)**. The lower cervical spine prefers to flex while the middle cervical spine extends which make the ideal lordotic human cervical spine **(Akçali, 2020)**. It holds the head's weight in an upright posture (the equivalent of 10 pounds) **(Hansraj, 2014).**

High-density concentrations of muscle spindles have been discovered in the deep cervical muscles and suboccipital muscles of the neck **(Saleh et al., 2018)**. When cervical muscles are not working properly like an imbalance between the deep cervical flexors and the stabilizers on the back of the neck, there is a loss of proper alignment and posture that results in cervical impairment and neck pain **(Rani & Kaur, 2022)**.

The cervical spine is made up of the superficial anterior, deep anterior, superficial posterior, and deep posterior muscle groups. These muscle groups must be flexible, balanced, and coordinated for the cervical spine to function normally. The neck is a complex structure, and several muscles in it help keep it stable and work properly. Chronic neck pain has been linked to diminished capacity and strength in the deep neck muscles, which account for 80% of the mechanical steadiness (longitudinal dynamic stability) in the cervical area and with prolonged postures of flexed neck **(Alshahrani et al., 2021; Namwongsa et al., 2018)**.

Neck pain has become a major public health concern due to its increasing prevalence and impact on daily life **(Ben Ayed et al., 2019)**. It is estimated that up to 70% of individuals will experience neck pain at some point in their lives. The condition can lead to decreased physical functioning, reduced quality of life, and increased healthcare costs. Additionally, neck pain is a major contributor to work-related disability and absenteeism, resulting in significant economic burden. With the rise of sedentary lifestyles and increased use of technology, the incidence of neck pain is likely to continue to rise **(Kazeminasab et al., 2022)**.

Musculoskeletal pain is a common issue among students, particularly those in medical fields, due to prolonged periods of studying and reading. According to a recent study conducted in Saudi Arabia, the prevalence of neck pain among medical students was found to be 68.5% **(Dighriri et al., 2019)**. Other studies have also reported neck pain as the most frequently reported pain site among college-aged students **(Behera et al., 2020)**. Poor ergonomics and psychological stress associated with academic workload have been identified as contributing factors to the high prevalence of neck pain among students **(Dighriri et al., 2019; Hasan et al., 2018)**. Moreover, prolonged sitting without taking sufficient breaks, along with improper head posture while working at a desk, have also been associated with neck pain in students **(Acaröz Candan et al., 2019)**.

Non-specific neck pain is often associated with reduced range of motion and pain in the neck area. This type of pain can occur without any identifiable pathology or structural abnormality, and may be accompanied by muscle spasm, trigger points, headaches, and limited range of motion **(Wingbermühle et al., 2018)**. Despite its prevalence, the underlying causes of non-specific neck pain remain poorly understood, although factors such as poor posture, stress, and repetitive strain injuries have been implicated **(Dixon et al., 2017)**.

Neck pain is a prevalent and burdensome condition that can result from a variety of factors. According to a recent study, the most common causes of neck pain include muscle strain and tension, poor posture, and degenerative changes in the cervical spine **(Lawrence et al., 2022)**. In addition, psychological factors such as stress and anxiety can contribute to the development of neck pain and can exacerbate existing symptoms **(Ortego et al., 2016)**. Other risk factors for neck pain include age, gender, and occupation, with individuals in physically demanding jobs or those that require prolonged periods of sitting at a desk being at higher risk **(Lawrence et al., 2022; Ortego et al., 2016)**.

Neck pain is a widespread issue that can lead to disability and decreased productivity. Recent studies suggest that neck pain is a significant problem in the workplace and can lead to decreased work performance and absenteeism **(Bealas et al., 2017)**. In response, healthcare providers are shifting toward a more holistic approach that considers not only the physical symptoms of neck pain but also the impact on daily activities and social participation. **The American Physical Therapy Association** released guidelines for the management of neck pain that emphasized the importance of patient-centered care and the use of multidisciplinary approaches to address the complex nature of neck pain **(Maistrello et al., 2022)**.

Non-specific neck pain is a common condition that can have a significant impact on upper limb function. Studies have shown that individuals with neck pain often experience reduced grip strength, decreased range of motion, and impaired hand function **(Asiri et al., 2021; Bracht et al., 2017)**. These functional impairments may be due to muscle weakness and imbalances, altered neural activation patterns, and changes in proprioception and kinesthetic awareness **(Canu et al., 2019)**. As a result, healthcare providers are emphasizing the importance of incorporating upper limb assessments and interventions into the management of neck pain, with the goal of improving overall function and reducing disability **(Alreni et al., 2015; Tsang et al., 2019)**.

Self-administered questionnaires are commonly used for functional assessment of neck pain in clinical practice. These tools typically focus on evaluating the individual's subjective discomfort, perceived impairment, ability to function or manage neck pain, and/or healthcare usage.

The Numeric Pain Rating Scale (NPRS) is frequently used as an outcome measure for assessing pain intensity in adults, including those with chronic pain resulting from rheumatic diseases. It is a segmented numeric version of the visual analog scale (VAS), where the respondent chooses a whole number between 0 and 10 to indicate the intensity of their pain **(Sharma et al., 2017)**. Additionally, The Neck Disability Index (NDI) is a condition-specific functional status questionnaire that is a modification of the Oswestry Low Back Pain Disability Index. It is a patient-completed questionnaire that includes 10 items related to pain, personal care, lifting, reading, headaches, concentration, work, driving, sleeping, and recreation. The NDI has received sufficient support and is considered useful, making it the most used self-report measure for assessing neck pain **(Young et al., 2019).**

Isokinetic dynamometry has emerged as a reliable and valid method for assessing muscle strength and joint function in individuals with upper limb disorders **(Webber et al., 2019)**. It has been used to evaluate muscle activation patterns, joint stability, and proprioception in the shoulder, elbow, and wrist regions **(Saini et al., 2022)**. Moreover, isokinetic dynamometers have been used to evaluate the efficacy of various rehabilitation interventions, including resistance training and neuromuscular electrical stimulation, for improving upper limb function in patients with neurological and orthopedic conditions **(Webber et al., 2019; Hatem et al., 2016)**. Given the benefits of isokinetic dynamometry, it has become an essential tool for clinicians and researchers in the field of upper limb rehabilitation. Furthermore, isokinetic testing of wrist flexors and extensors can be used to assess the effectiveness of various rehabilitation interventions, such as resistance training and neuromuscular electrical stimulation, in improving wrist muscle function in patients with wrist disorders **(Seven et al., 2019; Ağırman et al., 2017)**.

Hislop and Perrine initially introduced the idea of isokinetic motion in 1967, although Perrine produced the first isokinetic prototype in 1962, with angular velocity ranging from 0 to 3.75 revolution per minute (RPM). But not until 1968 that the Cybex (0 to 20 rpm), a passive isokinetic device for testing and rehabilitation, was introduced to the clinic. The Cybex II was released in 1975 and has angular velocities (0 to 50 rpm). By 1982, several isokinetic devices were produced. The first system capable of an isokinetic eccentric concentric contraction was the KinCOM, which was released in 1982. The Lido digital system, the Biodex, and the universal Merac were all introduced in 1983, 1985, and 1986, respectively **(Muñoz-Bermejo et al., 2019)**.

Various joint position matching tasks have been employed by many studies to assess proprioceptive abilities, and their findings revealed that those with neck and upper extremity disability had revealed positive correlation (**Shah & Sheth, 2018)** and additional studies revealed a statistically significant decline in wrist and shoulder proprioception in neck pain group compared to the healthy control group **(Abichandani & Parkar, 2017; Zabihhosseinian et al., 2015)**.

Isokinetic testing has been widely used to evaluate wrist strength and function. It provides an objective, reliable, and accurate measurement of muscle performance and coordination. Researchers have employed various speeds in isokinetic testing, such as 30°/sec, 60°/sec, and 120°/sec, depending on the task being evaluated. Additionally, both low and high angular velocities are frequently used in wrist assessment, with low velocities used for measuring maximum voluntary contraction and high velocities used for evaluating muscle coordination during functional activities **(Hasan et al., 2016)**. Isokinetic measurements of the wrist joint are taken from each participant at various points, including the maximum isometric contraction angle, concentric and eccentric strength, and muscle endurance angular velocities **(Ribeiro et al., 2021)**.

Wrist isokinetic dynamometry has been widely used to evaluate muscle function and identify the presence of muscular imbalances in the wrist joint, particularly in individuals with upper limb disorders and injuries **(Seven et al., 2019)**. The assessment of wrist isokinetic strength has been shown to be a reliable and valid tool for evaluating the strength and endurance of wrist flexors and extensors in both clinical and research settings **(Ağırman et al., 2017)**.

Although it is widely acknowledged that chronic non-specific neck pain is linked to hand disability, the assessment of flexor/extensor wrist strength ratio in this group has only recently gained attention. Furthermore, there is limited research investigating the strength control ratio that incorporates both concentric and eccentric muscle actions, and additional scientific evidence is needed to establish the relationship between chronic non-specific neck pain and upper limb disability, therefore in our study, we will be conducted to examine wrist muscle performance through peak torque of wrist extensor and flexor muscles to body weight**,** extensor / flexor wrist strength ratio and wrist extensor and flexor muscles endurance in chronic non-specific neck pain among Egyptian college students to evaluate functional ability of wrist in the upper limb in non-specific neck pain students to set new assessment and rehabilitation goals. This will subsequently be translated into home therapy program, contributing to decrease the burden of neck pain economically and on health care management.

Chapter III

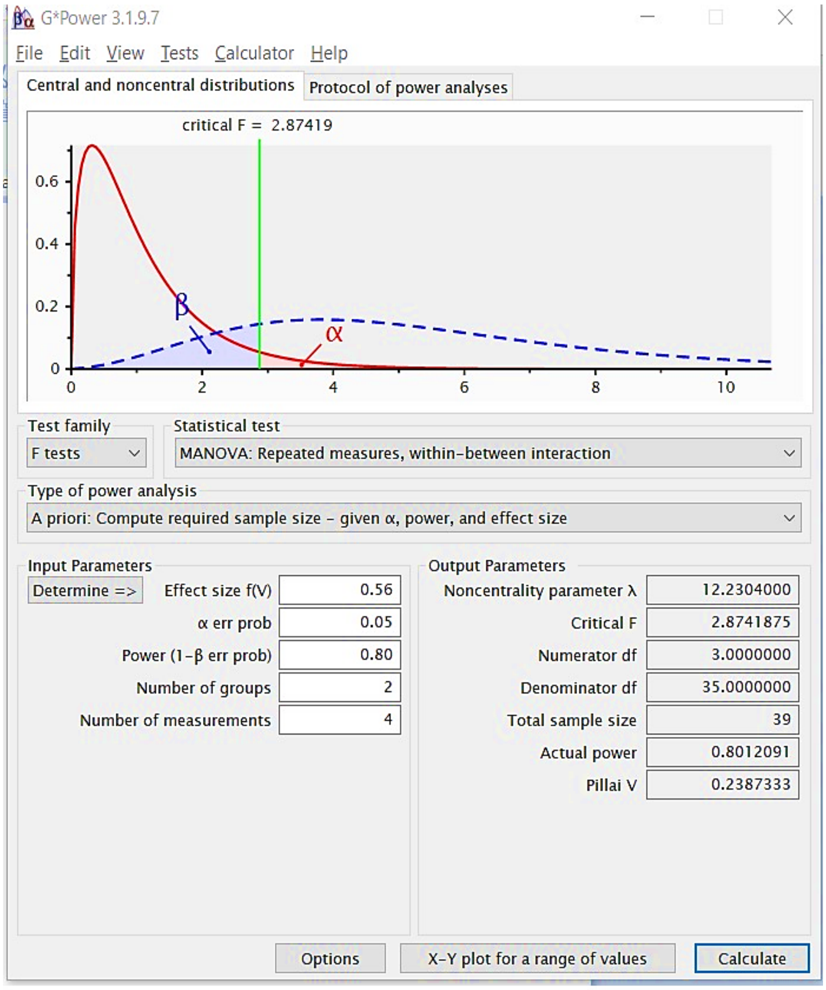
Subjects and methods

Our study aims to evaluate peak torque of wrist extensor and flexor muscle / body weight and extensor / flexor wrist ratio and wrist extensor and flexor muscle endurance among Egyptian physical therapy students with chronic non-specific neck pain. The practical part of the study is expected to be from May/2023 to December/2023 and will be conducted in the isokinetic lab in EL DELTA University.

Design: cross-section study

Sample size calculation:

Using G-power software (version 3.1.9.7; Franz Faul, Universitat Kiel, Germany) for windows and regarding MANOVA study, alpha level of 0.05, confidence level 0.80, and effect size 0.56, calculated from the previous study of **(Agirman et al., 2017)** that used the isokinetic dynamometer for measuring the 0peak torque of wrist with a sample of 35, and a two-sided alternative hypothesis, the sample size is 39 patients to be able to reject the null hypothesis. If 15% dropout rate is anticipated, approximately 44 patients (twenty-two in each group) will be recruited.



1. Students' selection:

The current study will be conducted on twenty-two non-specific neck pain Egyptian physical therapy students a with referral from orthopedic surgeons by diagnosis with non-specific neck pain other twenty-two without neck pain subjects from outpatient clinic of Faculty of Physical Therapy, EL DELTA University. Students' age ranges from 18 to 23 years. Students will be selected from faculties of physical therapy. Students will be assigned into two equal groups, the study group (GA) (chronic non-specific neck pain students) and the control group (GB) (normal students). They will be instructed not to participate in any training program until the posttest.

Inclusion criteria:

1- Students from both genders **(Fayez, 2014)**.
2- Duration of the non-specific neck pain is more than 3 months (for symptomatic group with no neurological manifestations and with referral from orthopedic surgeons by diagnosis with non-specific neck pain) and for matched students, they do not have any history of neck pain **(Chung & Jeong, 2018)**
3- Student' age ranges from 18 to 23 years.
4- Neck pain intensity on the numerical Pain Rating Scale will be between 3 to 8.
5- Neck pain-related disability on the Neck Disability Index will be between 5-14points (10 – 28%) mild disability and 15-24points (30-48%) moderate disability.
6- Body mass index for students will not be less than 18.5 and not more than 29.5 **(Alasadi, 2018)**.

Exclusion Criteria:

Any participant suffered from one of these symptoms will be excluded:

1- Indications of neurological conditions (i.e., Parkinson's disease, multiple sclerosis, head injury, peripheral neuropathy, stroke, or nerve root entrapment) **(Mahmoud et al., 2020)**.
2- Headache caused by a certain diagnosis of headache.
3- History of cancer, infection, or any other illness symptoms.
4- History of trauma, whether it was accompanied or not by structural issues with the neck, shoulder, or head (such as whiplash) within the last 12 months or any traumatic spinal cord injury **(Park et al., 2016)**.
5- Any known cardiovascular problems or cerebrovascular insufficiency symptoms.

6- Any known musculoskeletal disorder (i.e., joint replacement, amputation, physically limiting arthritis, contractures of fixed deformity or muscular dystrophy) which limits physical daily activities **(Bidja et al., 2018)**.
7- History of orthopedic or neurological conditions such fractures, surgeries on the upper limb or hand, carpal tunnel syndrome, De Qurvain's syndrome, or diabetic mellitus that result in functional defects of the hand strength **(Fayez, 2014)**.
8- Specific diagnosis of the cervical spine spondylosis, disc prolapse, spinal stenosis, cervical fracture, etc.
9- Subjects are also excluded if they have had any recent (within the last three months) treatment for neck pain **(Park et al., 2016)**.
10- Any medical condition affecting the sensory system (visual, auditory and speech problems).
11- Students are also excluded if they have had forward head posture.

2. Instrumentations

For Measurement and Assessment

- Photogrammetry posture analysis forward head (by the smartphone application forward head posture (FHP) as exclusion screening procedure to exclude subjects with abnormal forward head.
- Numerical Pain Rating Scale
- Arabic version of the Neck Disability Index (NDI)
- Arabic version of the Fatigue Severity Scale
- Isokinetic dynamometer

a) Photogrammetry posture analysis forward head:

Intra-rater reliability of the mobile application forward head posture had an intraclass correlation coefficient of 0.88. The inter-rater reliability generated an intraclass correlation coefficient of 0.83 to 0.89. Criterion validity data were above 0.82. The minimum detectable change was 4.96_ for intra-rater and 5.52_ for inter-rater reliability. The smartphone application exhibited 94.4% sensitivity and 84.6% specificity. The smartphone application forward head posture is a valid and reliable tool to measure craniovertebral angle (CVA) in a standing position and, therefore, could be a useful assessment tool in clinical practice **(Gallego-Izquierdo et al., 2020)**. The CV angle is the best indicator of FHP **(ShaghayeghFard et al., 2016)**. An angle less than 50-53 may indicate FHP **(Lee et al., 2015)**. Thereby, the smaller the CV angle, the greater the disability **(Cheung et al., 2009)**.

b) Numerical Pain Rating Scale (NPRS):

Numeric Pain Rating Scale (NPRS) has shown high test–retest reliability and for construct validity, the NPRS has shown to be highly correlated with the VAS in patients with rheumatic and other chronic pain conditions (pain>6 months) **(Young et al., 2019; Sharma et al., 2017) (Appendix II)**.

c) The Neck Disability Index (NDI):

The Neck Disability Index (NDI) demonstrated excellent internal consistency and good test-retest reliability. Content validity was confirmed as no floor or ceiling effects were detected for the Neck Disability Index (NDI) total score. Construct validity was established with factor analysis revealing two-factor subscales explaining 66% of the variance. The Neck Disability Index (NDI) showed a strong correlation with a visual analog scale (VAS) and a moderate correlation with the global rating of change (GROC) **(Lim et al., 2020; Young et al., 2019) (Appendix III)**.

The Neck Disability Index (NDI) (modification of the Oswestry Low Back Pain Disability Index). Patient-completed, condition-specific functional status questionnaire with 10 items including pain, personal care, lifting, reading, headaches, concentration, work, driving, sleeping and recreation. The NDI has sufficient support and usefulness to retain its status as the most used self-report measure for neck pain. The NDI can be used to evaluate the patient's status presence and to evaluate the evolution during the therapy.

d) The Fatigue Severity Scale (FSS):

Test-retest reliability and internal consistency of the Fatigue Severity Scale (FSS) is acceptable (intraclass correlation coefficient model 2,1 = 0.80; Cronbach's alpha = 0.84) with excellent internal consistency (Cronbach's α value 0.93) the concurrent validity of the Fatigue Severity Scale (FSS) appeared to be satisfactory due to the significant differences between people with MS and control subjects ($p < .05$). The correlations between Fatigue Severity Scale (FSS) and Multiple Sclerosis Impact Scale-29 (MSIS-29) physical ($r = 0.60$) and psychological ($r = 0.50$) subscale results confirmed the convergent validity of the FSS scale. Results also indicated that the best cut-off score is between 4 and 5 with a relatively high sensitivity and specificity **(Al-Sobayel et al., 2016; Jerković et a., 2022) (Appendix IV)**.

e) Isomed 2000 Isokinetic Dynamometer:

Isomed 2000 Isokinetic Dynamometer® (D&R Ferstl GmbH, Hemau, Germany) was used for collecting the isokinetic parameters. With the use of an isokinetic dynamometer like the IsoMed 2000 series, the peak torque and total work of isokinetic muscle strength test for wrist joint displayed good to excellent intra- and interrater reliability at low and high angular velocities in healthy youth **(Roth et al., 2017; Xu Jing-fei et al., 2012).**

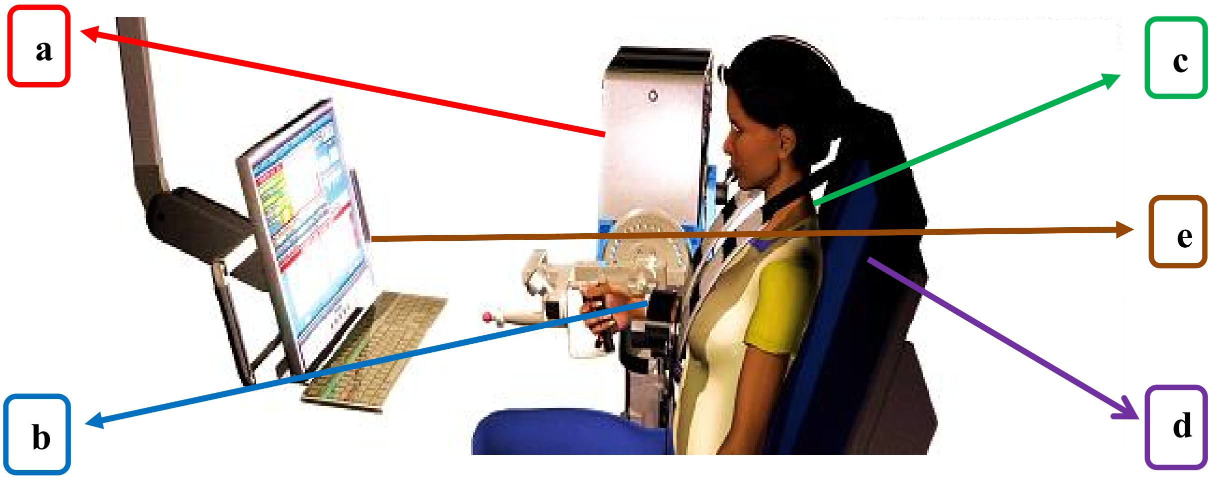


***Figure 3-2*: Isomed 2000 isokinetic dynamometer for wrist assessment: (a) Dynamometer, (b) Wrist attachment, (c) Chest strap, (d) Testing chair, (e) Control unit (computer system).**

3. Assessment procedure of the study:

The following section presents the testing procedure which will be passed by three phases: pre-experimental (preparatory), experimental and analysis of the captured data.

A. Pre-experimental (preparatory) phase

This phase involved participant preparation, pre-experimental instructions, and isokinetic system preparation.

Participant preparation

- All the subjects will be included according to inclusion and exclusion criteria and they will be selected from outpatients clinics of EL DELTA University. Then, after taking their individual demographic data, they will be assigned into two groups, the study group (GA) (chronic non-specific neck pain subjects without neurological manifestations) and the control group (GB) (normal subjects). After that, they will sign an informed consent form after receiving a brief orientation session about the nature of the study, the study purpose, procedure, possible benefits, and risks with preserving each subject privacy.

Measurement of craniovertebral angle to exclude subjects with abnormal forward head posture

Non-specific neck pain students will be evaluated to assess forward head posture by photographic posture analysis method by placing two markers on the ground separated by 1.5 m, where the smartphone and the subject will be located. Reference markers will be placed on the spinous process of C7 and in the swallow of the subjects' ears, which will be identified through palpitation. The subject will be placed on the floor mark, barefoot and standing, lateral to the evaluator. At this point. The evaluators will be experienced and trained physiotherapists **(Gallego-Izquierdo et al., 2020)**. The ones calculated with the FHP app will be classified attending to the presence or not of FHP. The presence of FHP (FHP group) will be determined by an angle value lower than 50, and the absence of FHP (no-FHP group) if the angle value will be greater than or equal to 50 **(Lee et al., 2015).**

Assessment of pain intensity by Numerical Pain Rating Scale

Also they will be evaluated to assess to assess pain intensity by Numerical Pain Rating Scale **(Appendix II)** as The Numeric Pain Rating Scale (NPRS) is a unidimensional measure of pain intensity in adults, including those with chronic pain due to rheumatic diseases. (man in pain, R) The NPRS is a segmented numeric version of the visual analog scale (VAS) in which a respondent selects a whole number (0–10 integers) that best reflects the intensity of his/her pain. The 11-point numeric scale ranges from '0' representing one pain extreme (e.g., "no pain") to '10' representing the other pain extreme (e.g., "pain as bad as you can imagine" or "worst pain imaginable"). As inclusion criteria, Neck pain intensity on the numerical Pain Rating Scale will be between 3 to 8.

Assessment of neck pain-related disability by Neck Disability Index

Also they will be evaluated to assess patients' self-reported neck pain-related disability, and the Neck Disability Index (NDI) **(Appendix III)** as the Neck Disability Index (NDI) (modification of the Oswestry Low Back Pain Disability Index). Patient-completed, condition-specific functional status questionnaire with 10 items including pain, personal care, lifting, reading, headaches, concentration, work, driving, sleeping and recreation.

The NDI can be scored as a raw score or doubled and expressed as a percent. Each section is scored on a 0 to 5 rating scale, in which zero means 'No pain' and 5 means 'Worst imaginable pain'. Points summed to a total score. The test can be interpreted as a raw score, with a maximum score of 50, or as a percentage. 0 points or 0% means: no activity limitations, 50 points or 100% means complete activity limitation. A higher score indicates more patient-rated disability. There is no statement in the original literature on how to handle missing data. Mean duration of the test: 3 to 7.8 minutes.

Some benchmarks can be found in literature: 0-4points (0-8%) no disability, 5-14points (10 – 28%) mild disability, 15-24points (30-48%) moderate disability, 25-34points (50- 64%) severe disability, 35-50points (70-100%) complete disability. As inclusion criteria, neck pain-related disability on the Neck Disability Index will be between 5-14points (10 – 28%) mild disability and 15-24points (30-48%) moderate disability.

Assessment of hand function and work performance by Fatigue Severity Scale

Additionally, they will be evaluated to evaluate patient perceptions of hand function, activities of daily life, pain, and work performance, Arabic version of the Fatigue Severity Scale **(Appendix V) as** the Fatigue Severity Scale is a 9-

item scale which measures the severity of fatigue and its effect on a person's activities and lifestyle in patients with a variety of disorders. A self-report scale of nine items about fatigue, its severity and how it affects certain activities. Answers are scored on a seven-point scale where 1 = strongly disagree and 7 = strongly agree. This means the minimum score possible is nine and the highest is 63. The higher the score, the more severe the fatigue is and the more it affects the person's activities. It is simple to understand and takes an average of eight minutes to answer.

- The participant’s personal data will be collected. The data include the participant’s name, age, address, weight, height, and phone number.
- All subjects of both groups will be tested for the isokinetic parameters twice (on dominant and non-dominant sides).
- The participant will be allowed to sit on the adjustable seat of the isokinetic dynamometer system.
- The tested arm will be placed on the limb support pad and secured with strap. Then the tested hand will be securely fastened with wrist attachments.
- The dominant hand is the one preferred by the participant to write or manipulates objects.
- Shoulder and waist straps will be placed around the chest to secure and stabilize the patient. In addition, the untested limb will be placed in a rest position and secured by strap,

Measurement of muscle performance of wrist by isokinetic dynamometer

This involves:

1) Measuring peak torque of wrist extensor and flexor muscles /body weight among Egyptian physical therapy students.

2) Measuring extensor / flexor wrist muscles ratio among Egyptian physical therapy students.

3) Measuring wrist extensor and flexor muscles endurance among Egyptian physical therapy students.

1- pre-experimental testing instructions:

- Before the actual isokinetic testing procedures, each participant will perform one practice series of three sub-maximal wrist extension and flexion repetitions to get accommodated with the specificity of the isokinetic speed of movement and wrist ROM. That will be done to minimize any practice effect during the actual testing procedure.

2- The isokinetic system preparation:

- The isokinetic system was powered, initialized, and calibrated.
- The dynamometer was rotated to 0°and was tilted to 0°.
- Wrist Attachment of dynamometer will be attached by placing input tube on dynamometer then it will be rotated horizontally to the floor to be aligned with the dynamometer shaft red dot.
- The testing chair was rotated to 0° degrees and seat back tilt was set to 85 degrees.
- The participant sat on the chair and the wrist axis of rotation will be aligned with dynamometer lever arm as discussed later in participant preparation.
- Axis of rotation for this pattern lies between the proximal row of the carpals, at the capitate bone, and the radius at the radiocarpal joint.
- The isokinetic parameters will be tested at angular velocity of 60°/sec. The testing velocity was selected from the control panel. The rationale for choosing this speed was based on previous studies. The literature suggested that wrist measurements will be taken from each participant at

the points where the dynamometer equipment was adjusted at 60°/sec for measuring muscle strength and 180°/sec for measuring muscle endurance angular velocities **(Janicijevic et al., 2020)**. Fast speed is for power, whereas slow speed is for strength. Reports by researchers have been employing both 60° and 120°/sec in isokinetic assessment for strength and power.

- Before being raised to this position, the dynamometer's range of motion will be adjusted to a total of 80 degrees, comprising 40 degrees of wrist flexion and 40 degrees of wrist extension **(Seven et al., 2019)**.
- The concentric/concentric mode was used to measure the wrist muscles peak torques, power and endurance.

B. Experimental phase

This phase involved experimental testing procedures for measuring peak torque of wrist extensor and flexor muscles /body weight, extensor / flexor wrist ratio and wrist extensor and flexor muscles endurance among Egyptian physical therapy students.

The experimental testing procedures will be conducted for all the participants of both groups.

- Following warm up, each participant will be positioned according to the instruction described before.
- The personal data of each participant will be introduced into computer, which includes participant name, age, sex, identification number and weight.
- The test protocol that will include the wrist ROM, the testing velocities, the mode of contraction and the test repetitions will be selected from the control panel.
- Each participant will be instructed to perform five sets of wrist extension and flexion at the selected wrist ROM (60°).

- Verbal encouragement will be given during the testing procedure to maximize the participant's voluntary effort.
- Wrist extensors and flexors will be tested at the concentric mode of muscle contraction using 60°/sec angular velocity.
- A 1- min rest will be given between warm up and actual test sequence.
- Testing procedures will be performed twice, on the dominant and non-dominant sides for both the study and control groups.

C. Analysis of the captured data

After performing isokinetic testing, the final output data were displayed after being processed by the relevant isokinetic software in the form of tables and graphs. The peak torque normalized for Bodyweight (Nm/Kg) for the wrist extensors and flexors/body weight were used to calculate the wrist flexor/extensor muscles strength ratio

$$\text{Wrist strength ratio} = \frac{\text{Peak torque of wrist flexors}}{\text{Peak torque of wrist extensors}}$$

Data Analysis:

The statistical measure will be performed through the statistical package for social sciences (SPSS) version 25 for windows. It will be intended to compare between the experimental and control groups for the wrist flexors/extensors strength ratio for both dominant and non-dominant sides.

Statistical Analysis:

- The statistical measure will be performed through the statistical package for social sciences (SPSS) version 25 for windows.

- Descriptive statistics in the form of mean and standard deviation will be used.

- Unpaired T-test will be used to investigate the comparison between two groups for numerical data.

- Chi-Square will be used to investigate the comparison between two groups for categorical data.

- One way between subjects' multivariate analysis of variance (One-way MANOVA) is useful in experimental situations where at least some of the independent variables are manipulated.

- The alpha point of 0.05 will be used as a level of statistical significance

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