A Study of Posture as a Suspected Cause of Carpal Tunnel Syndrome

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Abstract

The purpose of this study was to examine the peak torque of the wrist joint at different postural levels. Thirty repetitions performed on the Biodex Isokinetic System at different degrees of flexion by the subjects allowed the researcher to identify the wrist joint’s muscle fatigue, peak torques, and workloads over time. The results from this study provided the researcher with objective data for establishing worksite public health education programs for carpal tunnel syndrome prevention as well as many other types of physical injuries.

Key Words: Median Nerve, Carpal Tunnel, Biomechanical, Prevention, Muscle torque.

Section 1  
INTRODUCTION  
We live in a society that deals every day with work related injuries. Within the last thirty years, our society has started to notice the effects of musculoskeletal disorders on productivity in the work place. Health scientists seek to understand the injuries that occur within the work place, as well as causative factors associated with the injuries. Such an understanding is a critical step in prevention. Tracing injuries back to their underlying causes helps health scientists establish prevention programs to reduce the amount of worker displacement and psychosocial anguish and, therefore, increase productivity. The World Health Organization characterized work related diseases as multifactorial, composed of physical, work organization, psychosocial, individual, and sociocultural factors (Centers for Disease Control and Prevention [CDC], 2012).

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Many epidemiological studies over the last thirty years have analyzed work related illnesses. The goal of most, if not all, of these studies was to reveal causative factors of worksite injuries. The results of the majority of the studies identified the most problematic area of injury as the upper extremities (CDC, 2012).

Each year since 1972, the Bureau of Labor Statistics of the United States Department of Labor administers the Annual Survey of Occupational Injury and Illness, the only survey of its type in the nation. Its random sample began with a population of about 250,000; however, this sample excludes self-employed workers, farms with fewer than eleven employees, private households, and all government agencies. The survey provides basic information about causes of occupational injury, divided into four subcategories: fatal injuries, fatal illnesses, nonfatal injuries, and nonfatal illnesses. Both of the nonfatal categories contained musculoskeletal injuries (Bureau of Labor Statistics, 2012). In order to reduce occupational injury and illness, studies must focus on musculoskeletal injuries associated with repeated trauma (repetitive injuries).

A survey, conducted by the Centers for Disease Control and Prevention in 1995, reported 308,000 cases of illness related to repeat trauma, representing 62% of total injuries and illnesses declared. The numbers steadily climbed from 23,800 cases in 1972 to over 332,000 cases in 1994, followed by a seven percent decrease in 1995 (CDC, 2000). More strict health and safety regulations or an increased awareness through health promotion techniques and prevention awareness programs may have contributed the decrease. The Centers for Disease Control redesigned the survey in 1992. Required responses to the new, more comprehensive CDC survey contained the employer’s description of the injury, identified the injured body part, and named the source of the injury and how it occurred (Bureau of Labor Statistics, 1995).

In 1995 the Bureau of Labor Statistics reported that, combined, overexertion and repetitive motion led to over 32% of 705,800 cases of occupational injuries. Overexertion in lifting accounted for 367,424 injuries. Another 93,325 injuries resulted from pulling. Repetitive motion caused 92,576 injuries and 68,992 injuries stemmed from overexertion in holding, carrying, or turning objects. Over 47,861 injuries affected the shoulder. The median time away from work was six days from lifting injuries, seven days from pulling or pushing injuries, and six days from holding or carrying items. Employees suffering from repetitive motion injuries missed an average of 18 days of work (Bureau of Labor Statistics, 1995).

With advances in modern science and technology there was hope that the United States would have a reduction in musculoskeletal injuries. However in 2011, sprains, strains, overuse injuries and tears accounted for 447,200 injuries resulting in 44.4 percent of total injury and illness cases requiring days away from work. In 2011 the United States had 357,750 upper extremity injuries. Repetitive injuries such as Carpal Tunnel Syndrome required a median of 25 days off from work (Bureau of Labor Statistics, 2012). The number of days lost and the amount of money involved in salaries and health benefits demonstrates the need for research to pinpoint ways to lower these numbers.

Section 1.2
Need for the Study
Due to the high number of physical problems in the industrial world related to muscle strains in the forearm, leading to a high incidence of carpal tunnel syndrome problems, the researcher decided to focus this research primarily on finding scientific methods to prevent carpal tunnel syndrome. Carpal tunnel syndrome is the compression of the median nerve while the nerve impulses pass through the carpal tunnel structure in the wrist, which can lead to pain, tingling or numbness in the hand. Research has shown that improper ergonomics in the work place can lead to serious musculoskeletal disorders (Armstrong, Buckle, Fine, Hagberg, Jonsson, & Kilbom, 1993).
Work-related musculoskeletal disorders occur when there is a mismatch between the physical requirements of the job and the physical capacity of the human body. More than 100 different injuries can result from repetitive motions that produce wear and tear on the body. Back pain, wrist tendonitis and carpal tunnel syndrome may all stem from work-related overuse. Specific risk factors associated with musculoskeletal injuries include repetitive motion, heavy lifting, forceful exertion, contact stress, vibration, awkward posture and rapid hand and wrist movement (CDC 2012).

Swelling of the carpal tunnel structure compresses the median nerve and blood supply. Such compression can result in pain throughout the wrist and the palm side of the hand, as well as a loss of grip strength, causing an inability to perform certain types of movements (Armstrong et al., 1989). Evidence supports a positive relationship between carpal tunnel syndrome and high repetition activity. Repetitive activities cause an increase in pressure in the carpal tunnel through the swelling of the surrounding muscle tissue. Elevated pressure in the carpal tunnel can compress and damage the median nerve, thus slowing conduction velocity. Pressure left untreated continues to build and may permanently damage the circulation of the hand, increasing the chances of edema (fluid build-up) in the carpal tunnel (Rempel, 1994).

In the worksite, the health educator must analyze possible threats to employees’ health while working for the company. The document, Healthy People 2010, outlines specific objectives for worksite health promotion. According to goal seven, objective five, more worksites ought to offer comprehensive employee health promotion programs to their employees. A reduction in work-related injuries resulting in medical treatment, lost time from work, or restricted work activity accomplishes goal twenty, objective one. Goal twenty, objective three from Healthy People 2010 relates to the area of reducing the rate of injury and illness cases involving days away from work as a result of repetitive motion or overexertion (Healthy People 2010). Health educators should inform employees about repetitive injuries, because the consequent muscle strains represent one of the leading injuries workers face today (CDC, 2011).

Section 1.3
Significance of the Study
The study examined the nature of repetitive motion and force to the wrist as they relate to carpal tunnel injuries. Once health educators understand how and when injuries occur, they can establish health education programs to educate both management and workers to prevent the problem.

Health education focuses on primary prevention techniques, which provide people with essential information to reduce their chances of hurting their bodies. The data produced from this study provides health educators with objective information that could be utilized to plan effective health education programs. Some of the solutions could involve the development of a number of different strategies, such as adjustment of the employees’ workday. Stress management techniques would allow workers to focus on relaxation methods to reduce muscle tension that causes fatigue and swelling, resulting in increased pressure on the carpal tunnel (Maizlish, N., Rudolph, L., Dervin, K., & Sankaranarayan, M., 1995). As another approach, the health educator might recommend redesigning daily activities to prevent employees from lifting heavy objects after operating vibration equipment (Higgs, Young, Seaton, Edwards, & Feely, 1992).

Section 1.4
Purpose of the Study
This study intended to examine the peak torque (maximum muscle contraction) in a series of flexions and extensions of the wrist joint at different postural levels. Thirty repetitions performed on the Biodex Medical
System (a device that measures muscle strength) by the subjects revealed the wrist joint’s muscle fatigue, peak torques, and workloads over time. This test allowed the researcher to gain further understanding of the causes of carpal tunnel syndrome in order to establish worksite health education programs dealing with carpal tunnel syndrome (Biodex Medical System, 2013).

Section 1.5
Hypothesis
Angles of shoulder flexion at 60 degrees results in a decreased average peak torque of the forearm muscles. When testing the subjects’ wrist flexion/extension with 30 continuous repetitions of muscle contractions on the Biodex System, muscles undergo fatigue at 60 degrees of flexion, possibly resulting in the swelling of the carpal tunnel.

Section 1.6
Rationale
The shoulder posture level of 60 degrees was used because 60 degrees was the most non-evasive postural level to test for weaknesses in forearm strength (Magee, 1992). If strength loss was detected at 60 degrees of shoulder flexion it would be assumed that any activity 60 degrees or higher would accelerate forearm strength loss.

Section 1.7
Setting of the Study
The study took place at a large midwestern university. To reduce bias, participants performed the tests in a lab, rather than the worksite, to ensure that they felt no other stimuli during the test. The Biodex Medical System utilized for the study was housed in the laboratory of the Physical Therapy Assistant Program.

Methods

Section 2
Sample
Students between the ages of 18 and 24, who reported no history of neurological disorders or previous wrist injuries, participated. Alpha level was set at .05. Following a procedure described by Kirk, the researcher determined an appropriate effect size of $d=.5$. Therefore, this study required a minimum of 60 subjects to ensure a power of .80, necessary for experimental research using a formula from Kirk (Kirk, 1995). To secure a sufficient sample, the researcher recruited 70 subjects. Use of the random numbers table selected 60 subjects, keeping the extra ten in reserve to replace any selected test subjects who withdrew. Assigning each subject a number (1-60) from a random numbers table facilitated the simple random selection process. Randomly picking a number on the random numbers table, the researcher proceeded up and down the columns from left to right picking the subject’s numbers. After selection of the sample, the researcher assigned an equal number of males and females to the experimental group and the control group.

In an orientation, the researcher explained procedures and answered any questions each participant might have about the study. If, for any reason, a subject dropped out of the study he or she was replaced randomly by using the random numbers table to assign a participant from the reserve pool. The sample consisted of 20 females and 40 males.
Section 2.1
Intervention
The control group performed 30 concentric and eccentric contraction repetitions in a row with the shoulder at zero degrees of flexion. The experimental group performed 30 concentric and eccentric contractions in a row with the shoulder at an angle of 60 degrees of flexion. The experiment allowed the researcher to gain a further understanding of each participant’s strength gains or decreases when repetitive activity takes place at 60 degrees of flexion.

Section 2.2
Data Collection Procedures
The semester prior to data collection, Human Subjects approval was sought and granted. When participants arrived for testing, the researcher described in detail the motions of wrist flexion and extension and how they would be measured. Each participant completed a medical questionnaire. The participants learned about the study and carpal tunnel syndrome, but each of the subjects was blinded to which group he or she had been assigned, helping to eliminate bias from the participants. To ensure confidentiality and anonymity, each participant received an assigned identification number, eliminating the use of names with the data.

In order to eliminate participants with shoulder or wrist injuries or neurological injuries to the upper extremities, each subject submitted to an upper extremity neurological exam and manual muscle test before he or she was cleared to participate in the study. The testing procedures usually took ten to fifteen minutes to perform, specifically testing the dermatomes and the myotomes of Cervical vertebrae 1 through Thoracic vertebrae 2. The researcher conducted the tests of Cervical vertebrae 1 through Cervical vertebrae 8, and then showed the participants how to test themselves with Thoracic vertebrae 1 through Thoracic vertebrae 2 because the location of these dermatomes runs from the axillary to the midline of the chest. If the testing revealed an injury or neurological disorder, the researcher eliminated the volunteer from the study and replaced him or her with another subject selected by referring to the random numbers chart.

The experimental group performed 30 concentric and eccentric contraction repetitions in a row with their humerus at 60 degrees of flexion. The control group performed 30 concentric and eccentric contraction repetitions in a row with their humerus at 0 degrees of flexion.

Section 2.3
Data Analysis
The Biodex Medical System produces absolute data expressed in raw numbers for peak torque, which represents maximum muscle contraction and total work. Relative data, another source of data for analysis, compares an absolute value to another value. For example, what connection exists between peak torque data and acceleration parameters? The last data source method involved functional relative data composed of an absolute value in relation to body weight and time.

The data, raw numbers and relative data from the Biodex Medical System, revealed range of motion, torque parameters (peak torque), acceleration parameters, and force decay rate. Analysis of the range of motion curve detected specific force weaknesses in the wrist joint motion while performing flexion/extension. The torque parameters permitted the researcher to measure the peak torque (maximum muscle contraction). Measuring the peak torque curve allowed the researcher to better understand where the subject produced the most torque during flexion/extension, which assisted the researcher in identifying where the subject’s muscle
weakness took place. (See Figure 1) The mean torque (average of the maximum muscle contraction) data was the preferred measure because it combines averages of the entire peak torque curve, enabling the researcher to visually and numerically observe the effects of repetitive motion and its relation to strength loss.

The acceleration parameters helped the researcher understand when the peak torque occurs during the muscle contraction (See Figure 2). The researcher could determine the subjects’ fatigue rates because, if the peak torque occurs in the beginning one third of range of motion, then the subject would have little to no problem producing the muscle contraction of either flexion or extension. A peak torque located in the middle or final one third of range of motion indicates that the subject shows signs of weakness through the inability to generate torque on the onset of the muscle contraction (Biodex Medical System, 2013).

The force decay rate assisted the researcher in understanding the decrease in the torque production. If the subject’s force decay rate was a relatively straight or convex line of descent, then the subject completed a successful muscle contraction. A concave curve demonstrates that the subject had problems generating the necessary work force to complete the full range of motion (Biodex Medical System, 2013). See figure 3 below.

The last area of analysis involved muscle performance using functional relative data by observing the area under the range of motion curve. The printouts showed the total work of the muscle and figured muscle performance as force multiplied by distance.

All of these measurements, reported in raw numbers or graphs, provided data about when the muscles become fatigued. The researcher performed an independent t-test, the test for significant difference between two groups, using the peak torque data and Satterthwaite method to analyze the means between the control and treatment group.

Section 3

Results

Demographics

The relevant demographics were sex and age. The sample consisted of a total of 40 men and 20 women, divided and equally distributed into the control and experimental groups. The ages ranged from 18 to 24. Students from physical education classes volunteered for the study. Two subjects failed the health questionnaire and were replaced by participants from the reserve pool using the random numbers table.

Table 1 shows the control and experimental groups’ acceleration parameters. In the control group, 29 subjects achieved acceleration parameter peak torques in the beginning one third of the range of motion, demonstrating no difficulty with flexion or extension. Only one subject experienced a peak torque in the middle one third of the range of motion. This subject showed signs of muscle weakness. The control group had a greater capability to generate torque production on the onset of the muscle contraction. In the experimental group, three subjects produced their peak torque in the middle one-third and the other 27 subjects produced their peak torques in the last one-third of range of motion. The experimental group demonstrated muscle weakness and the inability to generate torque on the onset of the muscle contraction.

Table 2 shows force decay rates of the control and experimental groups. The force decay rate assisted the researcher in understanding the decrease in the torque production. The control group produced 24 straight lines of descent and six convex lines of descent in the range of motion. The control group completed a successful muscle contraction. In the experimental group, two subjects achieved a convex line of descent and
Table 3 illustrates the two groups’ means during the Biodex tests. Subjects in the experimental group performed 30 concentric and eccentric contraction repetitions in a row with their humerus at 60 degrees of flexion. In the control group, subjects executed 30 concentric and eccentric contraction repetitions in a row with their humerus at 0 degrees of flexion. The mean torque for the control group was 21.43 and the experimental group reported a mean of 11.68, demonstrating a difference of 9.75 between the control and experimental mean.

Table 4 illustrates the result of the independent t-test statistical analysis for the control and experimental groups. The assumption for performing the independent t-test was that the data of one sample (the control group) had no way of influencing the experimental group’s data. The analysis revealed a significant difference between the control group and the experimental group, calling for the use of the unequal variance t-test. The Satterthwaite method tested the homogeneity of variance based on the assumption of normality. For each case, it computes the absolute difference between the control group mean and the experimental group mean. The t-test resulted in a t value of 3.95 with a probability of the t at 0.0003, showing a significant difference between the two groups at an alpha level of .05.

Section 3.1

Findings
1. In the control group, 29 subjects achieved acceleration parameter peak torques in the beginning one third of the range of motion, demonstrating no difficulty with flexion or extension. Only one subject experienced a peak torque occur in the middle one third of the range of motion. In the experimental group, three subjects produced their peak torque in the middle one-third and the other 27 subjects produced their peak torques in the last one-third of range of motion.
2. The control group’s force decay rates resulted in 24 straight lines of descent and six convex lines of descent in the range of motion. In the experimental group, two subjects completed a convex line of descent and the rest of the 28 subjects produced a concave line of descent.
3. The mean torque for the control group was 21.43 and the experiment group’s mean, reported at 11.68, demonstrated a difference of 9.75 between the control and experimental mean.
4. The independent t-test resulted in a t value of 3.95 with a probability of the t at 0.0003, showing a significant difference between the two groups at an alpha level of .05.
5. This study demonstrated evidence of significant muscle torque loss when the humerus works concentrically/eccentrically with 60 degrees of shoulder flexion using the modern technology of the Biodex.

Section 4

Conclusions
1. Activities such as typing, in which shoulder flexion is at 60 degrees of flexion, cause a significant reduction in strength within the forearm muscles of the working limb. The experimental group showed a significant strength loss within the test of forearm strength.
2. Movements that require the individual to raise the shoulder to more than 60 degrees of flexion result in a significant strength loss in the forearm muscles over time.
3. Research shows that vibrations, even at low amounts, simulate repetitious activity in the body (Marras & Schoenmarklin, 1993). External vibration causes a decrease in forearm strength, putting the worker at risk for a possible injury. Since the experimental group suffered the most significant decrease in muscle torque production, those who work with a postural angle of 60 degrees would be even more vulnerable to this type of work. External vibration to the shoulder will cause strength loss.

Section 5
Discussion
The most compelling finding was the significant differences between the torque production of the control and the treatment groups. The instrument measured quantifiable differences in strength between the two groups for the concentric/eccentric contractions of the forearm muscles (Starkey, 1996). The isokinetic system enabled the researcher to isolate one joint at a time and measure the velocity and the strength of the joint (Biodex Medical System, 2013).

The Biodex Medical System simulated the high repetitive motions of employees from a wide variety of settings, allowing the researcher to observe the participants’ forearm muscle strength and weakness while performing the concentric and eccentric contractions. Such objective data can assist in the development of injury prevention programs. This study clearly demonstrates differences in muscle torque production resulting from different degrees of shoulder flexion and revealed that activities equaling 60 degrees of shoulder flexion or higher result in the inability of the forearm muscles to produce their normal peak torques (maximum muscle contractions). Health scientists can use this data to educate management and employees to adapt to their workstations through stress reduction seminars. Stress management techniques allow people to focus on relaxation methods to reduce muscle tension that causes fatigue and swelling, resulting in increased pressure on the carpal tunnel (Maizlish, N., Rudolph, L., Dervin, K., & Sankaranarayan, M., 1995). Improved ergonomic designs could help workers sustain their strength for longer periods of time, thus reducing the occurrence of muscle strains on the job. Analysis of muscle torque production identifies which body positions produce higher amounts of muscle torque over time, helping health scientists redesign workstations and reeducate workers on the importance of good body mechanics. Good body mechanics reduce the amount of muscle strains and hydrostatic pressure in the carpal tunnel. Another solution could involve an adjustment of the workday allowing for tired muscles to recover before the injury occurs.

This study attempted to target the high incidence of arm injuries due to repetitive motion by first identifying body mechanics, which allow for the greater amount of torque production of the forearm muscles. This data allows health scientists to develop more efficient health injury prevention programs through the use of objective data.

Section 5.1
Implications and Recommendations for Public Health
Based on the findings from this study and supporting studies the researcher makes the following recommendations.

1. In the worksite, continued effort should be made to change the intensity of physical work, such as adjusting work times to include breaks between the usage of vibration equipment and heavy lifting with the humerus at or exceeding 60 degrees of flexion. The literature states that the problem of worker injuries from muscle strains and sprains results from weakness and improper lifting techniques (Ikeda, Ishizuka, Sawanda, & Urushiyama, 1998). This present study clearly indicates a connection between outside vibration stimulus
and strength loss due to the loss of strength as repetitions increased. With an understanding of how our bodies work and adapt, researchers can help establish protocol for the use of machines that cause the arm to vibrate.

2. Public health educators in the worksite setting need a basic understanding of the human anatomy, allowing them to work as a team with occupational safety engineers, physical therapists, and occupational therapists. Once public health educators understand the language they can utilize all of the isokinetic data produced by other health professionals to strengthen their health injury prevention programs.

3. Public health educators should continue to work with and understand different worksite management techniques, such as Total Safety Management. A firm understanding of the managements’ view empowers the health educator to work more efficiently with both management and employees to understand the nature of the problem, as well as reasons to prevent the problem.

4. Public health educators should continue training to gain knowledge of different types of assessment technology. If health educators can understand the data produced by physical assessment technology, they could obtain more scientific data supporting the reasons for various components of their worksite injury prevention programs. Embracing technology equips health educators to handle changes in the future.

5. All worksite employers should perform Biodex testing on their employees to identify those at higher risk of developing carpal tunnel syndrome.

Section 6
Conclusion

The analysis of the data showed a significant difference between the experimental group and the control group. The experimental group demonstrated significant strength loss when the humerus was positioned at 60 degrees of flexion. This study intended to examine the peak torque of the wrist joint at different postural levels. The subjects performed 30 repetitions on the Biodex Medical System at different degrees of flexion, allowing the researcher to identify the wrist joint’s muscle fatigue, peak torques, and workloads over time. The results from this test provided the researcher with objective data for establishing worksite health education programs for carpal tunnel syndrome prevention.

The information gained from this study will lead to greater understanding of how the human body handles different types of jobs. This research focused on possible strength losses within the upper extremity when different degrees of posture are exerted on the arm. The researcher found significant differences between the control and the experimental groups. The control group, with no intervention, suffered little strength loss while the experimental group suffered a dramatic strength loss.

If worksite health educators know which upper body movements put more pressure on the carpal tunnel, they can plan prevention activities that lead to the reduction of injuries in all planes of movement such as teaching the employees good posture and proper ergonomics at their workstation. One of the goals of public health education is to focus on primary prevention techniques that provide people with the information necessary to reduce their chances of hurting their bodies. The data produced from this study helps provide health educators with objective information to utilize in the planning of effective worksite health education programs to deal with the problem of carpal tunnel syndrome. Once public health educators know what movements cause the injuries, they can better train employees on how to avoid injuring themselves.
References


Figure 1
Range of Motion Curve Revealing Peak Torque

Figure 2
Acceleration Parameters

Figure 3
Force Decay Rate
### Table 1

*Acceleration Parameters of the Control and Experimental Groups (N=60)*

<table>
<thead>
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<th>Beginning 1/3</th>
<th>Middle 1/3</th>
<th>Final 1/3</th>
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<tbody>
<tr>
<td>C</td>
<td>29</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>E</td>
<td>0</td>
<td>3</td>
<td>27</td>
</tr>
</tbody>
</table>

### Table 2

*Force Decay Rate of the Control and Experimental Groups (N=60)*

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<th>Convex Line</th>
<th>Concave Line</th>
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<td>Control</td>
<td>24</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Experimental</td>
<td>0</td>
<td>2</td>
<td>28</td>
</tr>
</tbody>
</table>

### Table 3

*Control and Experiment Group Mean Torques (N=60)*

<table>
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<th>GROUP</th>
<th>N</th>
<th>Mean</th>
<th>Std Dev</th>
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<tbody>
<tr>
<td>C</td>
<td>30</td>
<td>21.43</td>
<td>11.85</td>
</tr>
<tr>
<td>E</td>
<td>30</td>
<td>11.68</td>
<td>6.52</td>
</tr>
</tbody>
</table>

### Table 4

*t-Tests of the Control and Experimental Groups of the Study Sample (N=60)*

| Variable | Method     | Variances | DF  | t Value | Pr > |t| |
|----------|------------|-----------|-----|---------|------|---|
| BIODEX   | Satterthwaite | Unequal   | 45.1| 3.95    | 0.0003 |