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# Do eSports gamers differ from non-eSports gamers in posture, pain, and range of motion?

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**Abstract:**

*Objective:* The purpose of this research study is to compare posture, pain and range of motion (ROM) between young adult eSports gamers and non-esports gamers with similar sitting hours throughout an average week.

*Methods:* Subjects were recruited using social media and physical posts that included a screening survey. In total, 13 potential subjects were screened and 12 met the eligibility criteria. A total of four subjects were recruited to be assessed. Subjects were placed in either the eSports (N=2) or Control group (N=2) based on screening. Subjects were measured for ROM, posture, and pain characteristics. Independent sample t-tests and Pearson's Correlation Coefficient were used to analyze the groups. Further, due to low sample size, we combined the data of the two groups to assess the relationship of variables (ROM, posture, and pain characteristics).

*Results:* Baseline demographics data was similar between groups with independent t-tests of demographic data or variables assessed (ROM, posture, and pain characteristics). No significant differences were found in the outcome measures assessed. Pearson's correlation revealed massive confidence intervals resulting in no meaningful relationships. An insufficient number of subjects were assessed to meet power analysis.

*Conclusion:* This study was unable to find statistically significant differences between groups for any of the observed variables. The correlations found in this study suggest that anterior-posterior head shift may be correlated well with pain and ROM in the cervical region. This study may serve well as a basis for future research on this subject.

*Impact Statement:* Research targeted at identifying abnormalities correlated with the increasing popularity of competitive videogaming is vital to understanding the physical effects that may stem from this new trend. This study created a basis for future research design to examine the possible effects associated with extensive amounts of eSports gaming.

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## Introduction

Competitive gaming, otherwise known as "eSports", is one of the fastest growing sports around the world. The sport has grown to the point where "hundreds of millions of players" engage daily in some form of competitive video game activity.[1,2] One author defines eSports as a sport "in which two or more human players compete in video games with a defined set of rules."[1] Participation in eSports related activities, whether as a player or viewer, is becoming more common worldwide. For example, in 2017 the "esports League of Legends World Championship received 60 million viewers, whereas the National Basketball Association (NBA) attracted 20.4 million viewers."[3] This demonstrates the continued popularization of eSports to the point that it is outpacing the viewership of well-established traditional sports organizations. The increase in viewership and participation has directly influenced the earnings associated with the sport. In 2017, there was a combined estimate of at least $1.5 billion in earnings for eSports players.[2] Lastly, the popularity of eSports has expanded into American colleges as there are more than 50 varsity gaming teams.[2] Many of these colleges offer athletic scholarships to their gamers.[2]

Although the sport has recently made waves in the mainstream media, little research has been conducted focusing on the musculoskeletal health of this population.[1,2] Current research suggests certain negative health outcomes relating to eSports players that includes musculoskeletal pain, metabolic disorders, sleep disturbances, weight gain, behavioral changes, and vision problems.[4-6] Sedentary behavior in this population involves "performing tasks while sitting in front of a device screen" and this behavior is shown to be common with eSports players.[7] One study suggests that collegiate eSports players within the age range of 15-35 years old engage in sedentary behavior for 5.5 hours to 10 hours per day.[2] Similarly, another study focusing on collegiate eSports players within the age range of 17-29 years old estimated about 7.7 hours of sedentary behavior per day.[1]

Research on office workers is often referenced in the eSport literature due to the similarity in sedentary behavior. A common finding among both groups involves the development of musculoskeletal (MSK) pain along the spine and upper extremities.[6,8,9] Potential contributing factors include extended amount of time in the seated position as well as development of forward head posture.[6,8,9] Multiple studies found that collegiate eSports athletes reported neck and back pain (42%), wrist pain (36%) and hand pain (32%).[2,6] These findings further suggest that sedentary behavior and the prolonged sitting posture may have a role to play in the development of MSK pain.[2,6] Another study reported that the average play time in a population that consisted of amateur, semi-pro, or professional players was over 20 hours per week.[1]

Deviation from optimal sitting posture can be seen in eSports athletes within 30 minutes of gaming and may continue for up to 3-6 hours.[10] Zwibel et al reported the following on eSports athletes: common postural deviations and musculoskeletal imbalances leading to neck pain, slumped postures potentially leading to disk herniations in the lower back, strength deficits in the external rotators of the shoulder, and increased pain of the hand and wrist.[6] In addition, it is common to observe forward head displacement relative to the spine in computer playing eSports players.[6,10] The forward displaced head may potentially be leading to cervicogenic or tension-type headaches.[6,10] There are currently no research studies that specifically examine postural deviances and their relationship to MSK pain in eSports athletes that primarily play with keyboard and mouse. In addition, there were no articles found that provided comparative analysis to non-eSport sedentary groups. The purpose of this research is to compare posture, pain and range of motion (ROM) between young adult eSports gamers and non-eSports gamers with similar sedentary hours throughout an average week.

**Methods:**

*Materials and Methods:*

This was an observational, cross-sectional study. All subjects signed an informed consent form (Appendix 1) prior to participating in this study. Inclusion criteria were subjects between the ages of 16-35 years, speak fluent English or Spanish, and must sit for at least 20 hours per week. Subjects playing more than 20 hours of seated eSport games per week were allocated into the eSport cohort while subjects playing less than 20 hours of seated eSport games were stratified into the control group.

Exclusion criteria includes: age younger than 16 years or older than 35 years of age, no history of treatment for a musculoskeletal (MSK) condition of the spine, neck or upper extremities within the past year, and no prior diagnosis of pathoanatomic abnormalities (scoliosis, spondyloarthropathies, fused vertebrae, etc.) that may contribute to postural deviations.

In this study, we modified our original inclusion and exclusion criteria with the goal of attaining increased participation. The modifications made include: the age range was expanded from 18-35 years to 16-35 years, from a male only study to both male and female, we altered the control group's allowed eSports gaming time per week from a maximum of 5 hours to less than 20 hours, and physical therapy and physical therapy assistant students were originally exempt but were allowed to participate later in the study process.

A minimum of 68 subjects would be required to attain a power of 0.80 for this study. The subjects were equally distributed between the eSports gaming group (n = 34) and the control group (n = 34). Recruitment of subjects involved several methods: 1) placing fliers on university boards at two local colleges after securing appropriate approvals (University of Texas at El Paso (UTEP) and Western Technical College (WTC), 2) email to PT and PTA students by their program directors and 3) posting recruitment flier on two social media platforms: Facebook (915 Gamers, El Paso Smash Bros) and Discord (HB Valorant, Honey Badgers, El Paso Smash Bros Ultimate, NM

State Esports). Individuals responding to our advertisement completed a brief online survey (appendix 2) to determine if they met study eligibility criteria. The recruitment methods were selected as researchers felt posting on the selected social media platforms and physically in common college areas would result in high chances to contact adolescent and early age adults (16-35) that would meet our eligibility criteria. Data collected during this study was obtained through: a brief online survey (appendix 3), a physical assessment that includes measurements of active range of motion using goniometers and inclinometers, pain pressure threshold using a pressure algometer, and posture using the PostureScreen application (appendix 4). All testing was completed in a UTEP affiliated room. The same setup was used for all assessments to maintain a consistent environment throughout. To control for bias the researchers performing the measurements were blinded to the group status of all subjects while assessing posture, pain, and ROM. Recruitment of subjects began on December 1, 2021. Data collection period began on May 1, 2022 and concluded on December 15, 2022.

*Outcome Measures and Measure Method*

*Range of Motion (ROM)*

ROM was measured at the cervical spine, lumbar spine, and shoulder. ROM measurements were conducted following the guidelines published in the Norkin and White textbook.[12] For the cervical spine, one inclinometer was placed on either the most superior aspect of the cranium or the middle/anterior portion of the forehead. For the lumbar spine, two inclinometers were utilized and placed at the T12 and S2 vertebrae for lumbar flexion and extension. A skin marker was used to draw the landmarks and improve accurate placement of the inclinometers (Validity: Poor , Intrarater Reliability: ICC = 0.94, 95%CI (0.88 - 0.96), Interrater Reliability: ICC = 0.84, 95%CI (0.74-0.90), MDC: Unavailable, MCID: Unavailable).[11,] For the shoulder, goniometers were used to assess flexion, abduction, and internal rotation and external rotation at 90 degrees of abduction in the supine position (Validity: good - excellent , Interrater Reliability: 0.90 - 0.98 for all planes,  ICC = 0.79 - 0.98 , MDC: 6.8 - 15.1 degrees for all planes , MCID: Unavailable).[13]

*Posture*

The PostureScreen app (version 11.12) was used to provide analysis of resting posture and joint alignment for the cervical and thoracic spine (Validity: Unavailable, Interrater Reliability: Unavailable, ICC = 0.1 - 0.95 , MDC: Unavailable , MCID: Unavailable).[14] The PostureScreen app was utilized on an iPad Air 4th generation. Posture was assessed in a standing position from the sagittal and frontal plane. The app has a self-adjust feature that helps with orienting the camera to the subject's midline in the frontal plane and sagittal plane. The subject stood 10 feet in front of the camera and was instructed to stand as they normally would. The height and horizontal placement of the camera was kept consistent, while tile markers were used on the floor for subjects to align themselves properly within the frontal and sagittal planes.

*Pain*

Analysis of pain was performed using a Visual Analog Scale (VAS)(Appendix 5) of 0 to 10cm that was physically given to subjects on a piece of paper prior to physical examination (Construct validity: Excellent test-retest reliability in patients with knee osteoarthritis; ICC = 0.97; MDC: 0.08, SEM = 0.03 )[15].

*Pain Pressure Threshold (PPT)*

A pressure algometer was also used to measure the minimal amount of force required to evoke a pain report by the subject (Construct Validity: Good; Reliability: Good; MDC: 73.8-107.9 kPa depending on measurement site; MCID: not available).[16] Pain at rest was first assessed to determine baseline pain before initiating pain pressure threshold (PPT) assessment. The PPT assessment was conducted with pressure being applied to the upper trapezius, levator scapulae, and middle deltoid using a pressure algometer and the technique described by Wang-Price et al.[16] A limit was set at 87 psi, or 600 kPa, to avoid excessive pressures and bruising.[16] PPT analysis was performed after postural and ROM measurements to prevent the exacerbation of symptoms that may limit ROM measurements and alter posture.

*Statistical Analysis*

Demographic data was assessed using p-value $< 0.05$ and independent t-tests. Outcome measures of posture, pain and ROM were analyzed for statistical differences using independent two-tailed t-tests with unequal variances of the means assumed, p-value set at $< 0.05$ and included standard deviation (SD). The t-test and p-value results were produced by the Statistical Package for the Social Sciences (SPSS) technology. Power analysis was completed using the G-power calculation tool with following variables: independent t-tests, two-tailed, effect sizes ranging from 0.73 to 1.00, $\alpha$ was set at 0.05, power was set at 0.80, and a 1 to 1 allocation rate. These inputs revealed a range of 34 to 62 total subjects required for this study and 17 to 31 subjects per group. Pearson's correlation coefficient was used with the p-value set at $\leq 0.05$ for assessing the relationship of variables including cervical ROM, anterior-posterior head displacement, and upper trap pain pressure threshold.

## Results:

*Subjects*

Figure 1 below briefly outlines the recruitment process at each stage of this study. Thirteen individuals filled out this online survey to determine eligibility. Of the thirteen individuals that filled out our screening survey, twelve were determined to be eligible for this study. These twelve individuals were then contacted to arrange a date and time to collect data. Each subject was given an informed consent form containing a layout of the proceedings for data collection and then asked to sign the form prior to the admission of any tests. Of the twelve individuals that were determined to be eligible, only four male subjects decided to participate fully in this study. Of these four subjects, two met the requirements for the eSports group and the other two met the requirements for the control group.

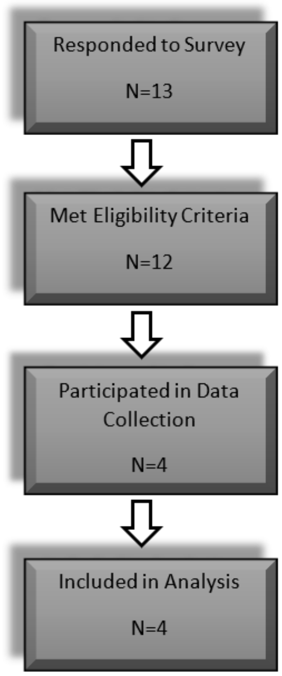


**Figure 1** Recruitment Process Diagram

*Descriptive Data*

Table 1 shows basic subject demographic information. Statistical analysis reveals there were no significant differences between the eSports and control groups as determined by an independent t-test, as such, it can be assumed that the groups are similar. All four subjects in this study were male and there were two subjects in each group.

| Demographics | | | | |
|---|---|---|---|---|
| | eSports Group Mean (SD) | Control Group Mean (SD) | t-test | p-value |
| Number of Subjects | 2 | 2 | - | - |
| Age (years) | 22.5 (± 3.5) | 29 (± 5.7) | -1.378 | 0.32 |
| Height (inches) | 67 (± 1) | 70.5 (± 1.5) | -1.941 | 0.21 |
| Weight (lbs) | 195.5 (± 19.5) | 206 (± 66) | -0.160 | 0.90 |
| | | | | |

**Table 1:** Participant Reported Demographics

*Main Results*

Weekly time expenditures for gaming and sitting are presented in Table 2. Level of significance was set at $p < 0.05$ for all variables. There was no significant difference for any of the reported time variables. Interestingly, although there is a notable difference in the average time spent playing esports games between groups, this difference was not significant. It is also important to note that the SD reported in this table are quite large, suggesting large variability in average times reported, particularly in weekly sitting time. This may be attributed to the small sample size acquired in this study.

| Weekly Time Expenditure | | | | |
|---|---|---|---|---|
| Variables | eSports Group Mean (SD) | Control Group Mean (SD) | t-test | p-value |
| Weekly Sitting Time (hrs.) | 60 (± 14.1) | 65 (± 35.4) | -0.186 | 0.88 |
| Weekly Time Spent Playing eSports Games (hrs.) | 40 (± 14.1) | 12 (± 5.7) | 2.600 | 0.18 |
| Weekly Time Spent Playing Activity-based Games (hrs.) | 0 | 4 (± 5.7) | -1.000 | 0.50 |
| Weekly Time Spent Playing Mobile-based Games (hrs.) | 0 | 6.5 (± 2.1) | 1.664 | 0.24 |
| | | | | |

**Table 2:** Weekly Time Expenditure

Table 3 contains all physical exam measures recorded and displays the associated independent t-test results. There was no statistically significant difference between group means for any of the physical exam measures.

| Independent Samples t-test for Equality of Means | | | | | |
|---|---|---|---|---|---|
| Data Collected | eSports Mean (SD) | Control Mean (SD) | p-value (two-sided) | Mean Difference | Std. Error Difference |
| Shoulder Flex (R) | 172.5 (± 13.4) | 180.8 (± 0.4) | 0.55 | -8.2500 | 9.5033 |
| Shoulder Flex (L) | 170.3 (± 17.3) | 179.8 (± 4.6) | 0.58 | -9.5000 | 12.6738 |
| Shoulder Abduction (R) | 153 (± 24.0) | 161.8 (± 4.6) | 0.70 | -8.7500 | 17.3079 |
| Shoulder Abduction (L) | 157.8 (± 16.6) | 161.8 (± 13.1) | 0.82 | -4.0000 | 14.9541 |
| Shoulder Internal Rotation (R) | 63 (± 12.7) | 81.8 (± 1.1) | 0.28 | -18.7500 | 9.0312 |
| Shoulder Internal Rotation (L) | 69.8 (± 18.0) | 80.8 (± 1.8) | 0.55 | -11.0000 | 12.8111 |
| Shoulder External Rotation (R) | 64.3 (± 5.3) | 81.3 (± 26.5) | 0.53 | -17.0000 | 19.1213 |
| Shoulder External Rotation (L) | 62.5 (± 2.1) | 83 (± 12.7) | 0.26 | -20.5000 | 9.1241 |
| Cervical Flexion | 53 (± 2.8) | 48 (± 0.7) | 0.23 | 5.0000 | 2.0616 |
| Cervical Extension | 59 (± 1.4) | 58.8 (± 5.3) | 0.96 | 0.2500 | 3.8810 |
| Thoracolumbar Flexion | 62 (± 7.8) | 48.3 (± 6.0) | 0.20 | 13.7500 | 6.9507 |
| Thoracolumbar Extension | 17.8 (± 5.3) | 13.8 (± 5.3) | 0.53 | 4.0000 | 5.3033 |
| Anterior-Posterior Head Shift | 0.3 (± 0.1) | -0.6 (± 0.8) | 0.39 | 0.8700 | 0.6067 |
| Anterior-Posterior Head Tilt | 2.7 (± 0.7) | 5.0 (± 7.0) | 0.73 | -2.2500 | 4.9752 |
| Neck Pain | 1.2 (± 1.0) | 0 (± 0) | 0.34 | 1.2000 | 0.7000 |
| Low Back Pain | 2.4 (± 2.8) | 3.4 (± 4.0) | 0.79 | -1.0500 | 3.4121 |
| Shoulder Pain | 0.6 (± 0.8) | 2.3 (± 3.2) | 0.59 | -1.7000 | 2.3162 |
| Wrist Pain | 0.8 (± 0.1) | 2.1 (± 3.0) | 0.64 | -1.3500 | 2.1006 |
| Upper Trapezius Pain | 8.5 (± 1.4) | 7.5 (± 2.5) | 0.73 | 1.0000 | 2.3707 |
| Levator Scapulae Pain | 9.7 (± 0.7) | 7.9 (± 2.4) | 0.56 | 1.7500 | 2.1290 |
| Middle Deltoid Pain | 9.4 (± 0.6) | 7.9 (± 1.1) | 0.34 | 1.5500 | 1.1413 |

| |
|---|
| |

**Table 3:** Independent Samples t-test for Equality of Means

Table 4 summarizes the data points closest to reaching statistical significance for easy visibility. The authors feel these are the most clinically relevant data from the cervical region across each category of measurement (ROM, posture, resting pain on VAS, and PPT). None of the reported data reached the statistical significance level ($p<0.05$).

| Independent T Test for Cervical Measures | | | | |
|---|---|---|---|---|
| | eSports Group Mean (SD) | Control Group Mean (SD) | t-test | p-value |
| Cervical Flexion (deg) | 53° (± 2.8) | 48° (± 0.7) | 2.425 | 0.23 |
| A-P Head Shift (in.) | 0.3” anterior (± 0.1) | 0.6” posterior (± 0.8) | 1.434 | 0.39 |
| Neck Pain (VAS) | 1.2 (± 1.0) | 0 | 1.714 | 0.34 |
| Upper Trapezius PPT (lbs.) | 8.5 (± 1.4) | 7.5 (± 2.5) | 0.422 | 0.73 |
| A-P Head Shift= Anterior-Posterior Head Shift; VAS= Visual Analog Scale; PPT= Pain Pressure Threshold | | | | |

**Table 4:** Independent T Test for Cervical Measures

Table 5 presents the correlations between cervical flexion, anterior-posterior head shift, neck pain on the VAS, and upper trapezius pain as determined by PPT. These correlations were selected to condense the vast amount of information to concentrate on the cervical spine and specifically reporting the data that would elicit the greatest correlations. This data shows that there is only one good to excellent relationship between A-P head shift and upper trapezius pain on PPT (0.775).[17] There are two moderate to good relationships between A-P head shift and cervical flexion ROM (0.726) and A-P head shift and neck pain on VAS (0.516).[17] There are two that fall into the fair degree of relationship which are neck pain on VAS and upper trapezius pain on PPT (0.503) and  neck pain on VAS and cervical flexion ROM (0.355).[17] Finally, the cervical flexion ROM and upper trapezius pain on PPT (0.133) fall into the little to no relationship category.[17] It is important to note that the confidence intervals for all of these correlations largely cross the zero point. This means that although some of these correlations appear strong, the data is not powerful enough to be considered meaningful.

| Key Data Correlations | | |
|---|---|---|
| | 95% Confidence Intervals (2-tailed) | |

| Variable Comparisons | Pearson Correlation | Lower | Upper | p-value |
|---|---|---|---|---|
| CervFlx- APHeadshift | 0.726 | -0.778 | 0.994 | 0.27 |
| CervFlx- NeckPainVAS | 0.355 | -0.920 | 0.981 | 0.65 |
| CervFlx- UTPainThreshold | 0.133 | -0.949 | 0.970 | 0.87 |
| APHeadshift- NeckPainVAS | 0.516 | -0.883 | 0.987 | 0.48 |
| APHeadshift- UTPainThreshold | 0.775 | -0.730 | 0.995 | 0.23 |
| NeckPainVAS- UTPainThreshold | 0.503 | -0.887 | 0.987 | 0.50 |
| CervFlx= Cervical Flexion; APHeadshift= Anterior-Posterior Head Shift; NeckPainVAS= Neck Pain on the Visual Analog Scale; UTPainThreshold= Upper Trapezius Pain Pressure Threshold | | | | |

**Table 5:** Key Data Correlations

**Discussion:**

The aim of this study was to compare posture, pain, and ROM between eSports gamers and adults with similar sitting times. Data was collected and analyzed for four subjects (eSports group = 2 males, control group = 2 males). Statistical analysis revealed there was no significant difference between the experimental group and control group in any of the posture, pain, PPT, or ROM variables assessed. The study was underpowered since the 60 subjects needed to meet the power were not recruited. As a result, the study was more susceptible to a type II error and made it more difficult to detect differences that may have been present.

Demographics between the eSports and control groups were similar at baseline (see Table 1). All four subjects were male. No female subjects were recruited despite physical and virtual efforts to include female subjects. Reports from individuals who filled out the surveys but did not participate in physical data collection listed class schedule, exams, residing out of town during school breaks, and lack of transportation as extraneous factors that prevented them from participating further in the study. Starting the recruitment process earlier, hosting data collection on main campus, accommodating data collection times earlier in the day, and advertising the study on other common platforms could have potentially increased the number of subjects recruited.

Sitting time variables did not elicit statistical differences between the eSports and control groups (see Table 2). The control group spent an average of 5 hours more sitting per week than the eSports group (65 hours vs 60 hours respectively). Further, the eSports group spent much more time playing eSports games per week than the control group (45 hours vs 12 hours respectively), however, this difference was not statistically significant either. Reasons for lack of significance may be due to the small sample size and underpowered nature of the study. The prolonged sitting time seen in both groups places the subjects at risk for developing chronic conditions. Also, it is common to note abnormal muscle length-tension in individuals with poor posture. Additionally, the subjects' overall cardiovascular fitness may be negatively affected by the high number of hours spent sitting regularly.

Physical examination variables were not significantly different between the eSports and control groups, however, some differences were observed (see Table 4). These differences may have become significant if we were able to recruit a larger sample size. The data reported in Table 4 compares Cervical Flexion, Anterior-Posterior Head Shift, resting Neck Pain on the VAS, and Upper Trapezius Pain as determined through PPT. The eSports group displayed greater cervical flexion ROM and anteriorly displaced head, whereas the control group exhibited less cervical flexion ROM and posteriorly displaced head. Although the eSports group reported greater neck pain at baseline, the group showed greater tolerance to pressure to the upper trapezius prior to pain onset. The eSports group's anteriorly displaced head may be attributed to the forward head posture that gamers commonly assume during extended gameplay.[10] The anterior head translation may be part of the reason the eSports group had increased cervical flexion ROM. Although not displaced anteriorly, the control group also displayed abnormal head posture that may be the result of sitting on average for 65 hours weekly. The eSports group may have had a higher pressure threshold prior to upper trapezius pain onset due to desensitization from existing resting neck pain.

Table 5 outlines the strength of the relationship among the condensed variables of interest. All the subjects were conjoined into a single group for this analysis due to the small sample size. A good to excellent correlation was discovered between A-P head shift and upper trapezius pain on PPT (0.775).[17] Increased anterior head shift in eSport athletes compared to the control group (0.3" anterior ± 0.1 vs 0.6" posterior ± 0.8 respectively) was related to greater PPT (8.5 ± 1.4 vs 7.5 ± 2.5 respectively). The correlation between A-P head shift and cervical flexion ROM (0.726) was classified as moderate to good. Increased anterior head shift in eSports athletes compared to the control group (0.3" anterior ± 0.1 vs 0.6" posterior ± 0.8 respectively) was related to increased cervical flexion ROM (53° ± 2.8 vs 48° ± 0.7 respectively). These results contrast common clinical expectations as forward head posture is associated with increased neck pain and decreased cervical flexion ROM.[18,19] The increased neck pain on VAS in the eSports group compared to the control group (1.2 ± 1.0 vs 0 respectively) was related to increased cervical flexion ROM (53° ± 2.8 vs 48° ± 0.7 respectively). This was not expected since there is a decrease in neck mobility with the presence of neck pain attributed to forward head posture.[19]

The correlation between A-P head shift and neck pain on VAS (0.516) were classified as moderate to good.[17] Increased anterior head shift in eSports athletes compared to the control group (0.3" anterior ± 0.1 vs 0.6" posterior ± 0.8 respectively) resulted in greater neck pain on VAS at rest (1.2 ± 1.0 vs 0 respectively). An increase in resting neck pain was expected, considering that when the head is more anteriorly displaced, there may be increased strain on the postural muscles of the neck.[18] The correlation between neck pain on VAS and upper trapezius pain on PPT and between neck pain on VAS and cervical flexion ROM fall into the fair degree of relationship category.[17] The increased neck pain on VAS in the eSports group in comparison to the control group (1.2 ± 1.0 vs 0 respectively) resulted in increased upper trapezius pain on PPT (8.5 ± 1.4 vs 7.5 ± 2.5 respectively). The presence of resting neck pain may have allowed subjects to tolerate increased pressure to the upper trapezius since the subjects have grown accustomed to painful stimuli already. Lastly, a little to no correlation was found between cervical flexion ROM and upper trapezius pain on PPT (0.133).[17] The eSports group displayed greater cervical ROM compared to the control group (53° ± 2.8 vs 48° ± 0.7 respectively), which resulted in an increased upper trapezius pain on PPT (8.5 ± 1.4 vs 7.5 ± 2.5 respectively). Subjects in the eSports group were able to achieve greater cervical flexion ROM since pain was not acting as a limiter to motion. Increased anterior head shift appeared to have the greatest influence on neck mobility and pain compared to the other variables analyzed. Despite the correlations found, they cannot be considered meaningful since the SD vastly crosses zero. The correlations described here are merely examples of what may be found if the relationships were determined to be significant.

*Limitations*

The primary limitation of this study is the lack of sufficient number of subjects to meet our power analysis of 30 subjects in each group. There are several reasons that may have contributed to the lack of subjects. For example, data collectors were limited to evenings on weekdays and over the weekend due to clinical rotation commitments. Potential subjects were unable to secure transportation or the data collection site was inconveniently located. This small sample size limited the ability to obtain accurate data from the population of interest and to find any significant differences among the groups, if there was any present. Additionally, the sample size did not include females in either group, although they were included within the eligibility criteria. No female filled out the second survey, which was the first questionnaire to contain a question for specifying sex. The lack of female subjects coincides with the predominantly male dominant nature of eSports.[1] Future studies should tailor recruitment advertisements specifically to females to increase the likelihood of female participation. The sample size also included physical therapy students, who have knowledge of proper posture and normal ROM values. This could have potentially influenced their performance in the study. The questionnaires contained self-reported data, so there is also the possibility that the information such as sitting times provided were under or over-estimated. Finally, this study was performed using a rather broad spectrum of measurements in an attempt to find statistical significance between groups. This vast amount of data complicated the statistical analyses for this study and could have been more focused if a more regionally targeted approach was utilized.

*Generalizability*

The findings of this study are best applicable to young adult male eSports gamers since that is what the sample size consisted of. The findings may not be applicable to youth and female eSports gamers. Although some trends among the variables of interest were noted, caution should be used in clinical application as no statistical difference in baseline physical examination were found, underpowered nature of study, and generally large standard deviation of the means. Despite the differences between groups not being significant, the differences found coincide with similar findings in published literature involving posture, pain, and ROM in eSport gamers.[2,4] Therefore, efforts should be made to produce research that can educate eSports gamers to minimize risk for injury. This production of research can also be used for healthcare professionals to help deliver better care for this special target population.

*Recommendations for Future Research*

To our knowledge, there have not been studies published that compare an eSports group to a sedentary control group in these measurements concerning ROM, posture, and pain. The data collected in this study, although inconclusive due to limited power, suggests there may be correlations between select physical exam measures and pain in eSports and control subjects. Future research should target specific regions of the body, such as the cervical or shoulder regions, rather than attempting to concentrate on all theorized regions that may be affected. Furthermore, researchers must consider additional methods to those used in this study and longer timeframes for data collection to maximize ability to recruit an adequate number of subjects.

*Conclusion*

This underpowered study did not find any statistically significant differences between the eSports group and the control group on any variable assessed potentially due to the underpowered nature of this study. However, there were some correlations between key assessed measurements, which include increased forward head posture correlating with increased upper trapezius PPT, increased cervical flexion ROM, and increased neck pain on VAS. Additionally, a correlation between increased cervical flexion ROM and increased upper trapezius pain on PPT was observed. The methodology utilized with modifications in recruiting can serve as a template to guide future research to assess the similarities and differences between eSports gamers and adults with similar sitting frequency regarding posture, pain, and ROM.

**Other Information:**

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Supplementary Data

[Appendices.docx - Google Docs]