

**ORIGINAL ARTICLE****EFFECT OF PROLONGED SITTING DURATION ON THE RISK FOR MUSCULOSKELETAL DISORDERS AMONG PC GAMERS**

Muhammad Nur Luqman CHUMARI<sup>1</sup>, Mohd Razif MAT HASAN<sup>2</sup>, Ammar ADNAN<sup>1</sup>, Radin Zaid RADIN UMAR<sup>3</sup>, Siby SAMUEL<sup>4</sup>, 'Atiah ABDULLAH SIDEK<sup>1</sup>, Malek HAMID<sup>1,\*</sup>

<sup>1</sup>Department of Manufacturing and Materials Engineering, Faculty of Engineering, International Islamic University Malaysia, Kuala Lumpur, Malaysia

<sup>2</sup>Occupational Safety and Health and Build Environment Division, International Islamic University Malaysia, Kuala Lumpur, Malaysia

<sup>3</sup>Faculty of Manufacturing Engineering, Universiti Teknikal Malaysia Melaka, Melaka, Malaysia

<sup>4</sup>Department of System Design Engineering, University of Waterloo, Ontario, N2L 3G1, Canada

\* Corresponding Author: abdmalek@iium.edu.my

**ABSTRACT**

*In the era of booming gaming industries, gamers are exposed to prolonged sitting involving awkward posture and repetitive tasks that contribute to the risk for musculoskeletal disorders. However, there is no study have been done on the effect of prolonged gaming activities on the human trunk and neck postures. Thus, the objectives of the study are: (i) to evaluate the effect of prolonged gaming on the trunk posture by using the trunk posture analysis; (ii) to evaluate the effect of prolonged gaming on the trunk posture by using the trunk posture analysis; and (iii) to evaluate the discomfort level among the gamers during pre- and post-experimental session by using the Corlett & Bishop's Scale. Ten participants between 20-25 years of age [mean = 23.85; SD 1.16] completed the study where their activities during gaming were recorded for three hours. From the video output, their postures (trunk and neck) was scored by separating the data into three different categories - one-hour-data, two-hours-data, and three-hours-data. In addition, they also were asked to self-rate their discomfort level pre- and post-experimental session. The results show that: (i) the mean values of the trunk posture score of one-hour-data, two-hours-data, and three-hours-data are 2.12 [SD = 0.331], 2.15 [SD = 0.383], and 2.31 [SD=0.464] respectively; (ii) the mean values of the neck posture score of one-hour-data, two-hours-data, and three-hours-data are 2.13 [SD = 0.715], 2.01 [SD = 0.767], and 2.44 [SD=0.643] respectively; and (iii) the mean values of the self-rated discomfort level of pre- and post-experimental are 0.37 [SD = 0.669] and 1.90 [SD = 1.155] respectively, and the difference is 1.53 [SD = 1.196]. The findings show that prolonged gaming duration do affect the gamers, specifically on the trunk and neck posture that requires an awareness from the gamers.*

**Keywords:** Musculoskeletal Disorders, Gamers, Prolonged Duration, Posture Ergonomics

**INTRODUCTION**

Musculoskeletal disorder (MSD) is a pain or injury that affect human's musculoskeletal system such as muscles, ligament, tendon, nerve, and joint (Bridger, 2017; Jun, Li, & Mao, 2015). Its contributing factors include the adaptation of an awkward posture, repetitive action, extreme force exertion, and contact stress (Bridger, 2017). Musculoskeletal disorders have been shown to affect workers from numerous workplaces such as manufacturing company (Mustafa et al., 2009), university workers (Rahim & Tamrin, 2016); packaging industries (Shamsudin, Vijayakumar, & Daud, 2017), hotel industries (Rahman & Jaffar, 2017), and healthcare provider (Sukadarin et al., 2016). Social Security Organization (2017) reported that 12, 285 MSD cases were reported to SOCSO Malaysia from the year 2009 - 2014. Besides the workplace related tasks, daily activities also expose an individual to the risk for musculoskeletal disorders. In the era of booming gaming industries, gamers are not excluded to be exposed to the risk for musculoskeletal disorders.

Due to the growing number of players in the gaming industry, there has also been a rise of reports of musculoskeletal disorders among the gamers and e-sports professional (Lujan, 2017). Among the contributing factors for this situation is a prolonged sitting duration that involves gamers during gaming activities. Prolonged sitting with and addition of adopting several awkward postures and repetitive activities during the gaming would make the situation worst.

However, there have been relatively few studies were made regarding the importance of the ergonomics application on competitive gaming as an industry. Among the few research have been done on the effect of gaming activities were on the hand problems such as trigger fingers and carpal tunnel syndrome (Apendai, et al., 2017), eye strain and health (Mansor et al., 2017), as well as the sleep problem (King et al., 2013). However, there is no study has been done on the effect of prolonged gaming activities on the human trunk and neck postures. Thus, there is a need to investigate this particular effect of gaming activities.

The aim of the study is to evaluate the effect of prolonged gaming duration on the risk for musculoskeletal disorders. In order to achieve this aim, several objectives were determined, and they are; (i) to evaluate the effect of prolonged gaming on the trunk posture by using the trunk posture analysis (measured); (ii) to evaluate the effect of prolonged gaming on the trunk posture by using the trunk posture analysis (measured); and (iii) to evaluate the discomfort level among the gamers during pre- and post-experimental session by using the Corlett & Bishop's Scale (self-reported, subjective rating).

## METHODS

### Participants

Ten participants have completed the study. All participants were required to fulfil the eligibility criteria for the study which are, male college students, who are between 18-25 years of age, with a healthy current condition at the time of the experiment (e.g. no sign of fever, sinus, and etc.). These criteria were set so that all participants will have a similar demographic and daily routine activities and condition. This is because, gender (Sharma & Singh, 2014), age (Karibe et al., 2014), and daily routine i.e. physical job demands (Heiden et al., 2013) are among the contributing factors for the risk for musculoskeletal disorders. Ethnic background was not taken into account in the study, however, the information was collected for record purposes as have been practiced in other human subject studies.

### Apparatus & Stimuli

**Data Collection Equipment:** A standard computer workstation was set up for the experiment, and for the recording purposes a video recorder was used. The same computer workstation was used throughout the study. It consists of a CPU unit, an adjustable monitor (24"), speaker set, keyboard, mouse, and mouse pad. A video recorder (Panasonic HC-V210) was used for the experiment. Moreover, a tripod (Digi Eye TR-37) was used to stand the video recorder so that the recording will be static throughout the recording process. The video recorder was set up on the side of the mouse & mouse pad that the participant was preferred. In addition, it also was set up such that it covered the area from the top of the participant's head to the height of the chair (sitting height). A few clearances were considered in an assumption that a participant may move out from the mentioned area. This was to ensure that the participant's posture will be able to be scored during the scoring phases. During the playback, a data analyst was able to see all the video output (just like any other regular video recorder systems) and produce a snapshot at any particular time frame. The time frame of the system is ten seconds. In addition,

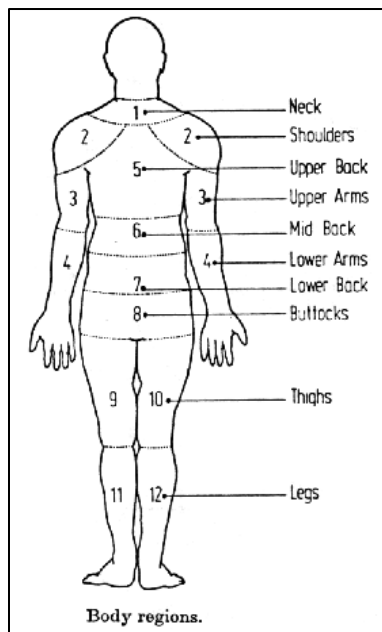
the time stamp and date will be on the output video.

**Scoring Forms:** The scoring forms used in the study were: (i) Trunk and Neck Posture Analysis Form; and (ii) Corlett & Bishop's Scale for Body Symptoms Survey Form. The trunk and neck posture analyses were adopted from one of the reliable postural analysis tools that are widely used in musculoskeletal disorders studies called Rapid Upper Limb Assessment (RULA) tool (McAtamney & Corlett, 1993). However, because gaming activities (in this study) is a sitting task and would involve a similar range of upper limbs movement, the RULA tool was simplified, in which, only the trunk and neck postures (parts of the RULA) were scored in this study. Thus, the Trunk and Neck Posture Analysis Form was designed (Figure 1). Basically, the form consists of three part: (i) a part to label the time interval (top part of the form: e.g. 5 means it is for the snapshot of the participant's posture at minute five of the video data); (ii) a part to paste the snapshot taken from the video data at the respective time interval (middle part of the form: i.e. in here, a data analyst took a snapshot from the video data and pasted it on this part of the form); and (iii) a part to score the posture (bottom part of the form: i.e. a data analyst scored the snapshot pasted above it). The complete data would have multiple scoring sheet for every 5-minutes interval (up to minute 180).

**Fig. 1 Trunk and Neck Posture Analysis Form (designed based on RULA by McAtamney & Corlett, 1993)**

The body symptom survey used in the study was Corlett & Bishop's Scale (Corlett & Bishop, 1976). Figure 2 illustrates the body diagram that is used to assess postural discomfort in Corlett & Bishop's Scale. This subjective scale required the participant to evaluate if he feels discomfort on a particular part of his body regions (illustrates by numbers, from 1 to 12). If a participant feels discomfort in that particular region, he was asked to label "X" on the number that represents his body region, and more than one "X" can be

labelled. A participant was required to give his response before and after the gaming session. This scale was chosen among other similar symptom surveys (e.g. (Department of Safety & Health Malaysia, 2017); (Crawford, 2007)) because of its simplicity yet reliable. This decision was made in order to reduce the load that a participant will have to spend on the study.



**Fig. 2** A body diagram for assessing postural discomfort (Corlett & Bishop, 1976)

**Administrative Documents:** In this study, there were several types of administrative documents were used. They are: (i) informed consent form; (ii) participant form - for data collection; and (iii) payment voucher.

#### *Experimental Design*

**Baseline posture setup:** At the beginning of the gaming session (timestamp = zero), participant was asked to sit in the condition that his trunk and neck were straight, as this is the ergonomic posture for a human - anatomical position (The American Academy of Orthopaedic Surgeons, 1965). This step was to ensure that a participant starts the gaming session with an ergonomic posture. Thus, it somehow would be the baseline to the scoring of the trunk and neck posture throughout the gaming session.

**Standard adjustable chair:** A standard adjustable chair was used throughout the study so that all participants would have a similar workstation setting. Moreover, this was also to ensure that a participant can adjust the chair so that he can sit ergonomically. However, participants are free to adjust the chair during the gaming session so that it mimics the real situation of gaming activities.

**Gaming Duration:** The experimental session was set to 3 hours (180 minutes) based on several gaming literature that considered that anything above 150 minutes as prolonged (e.g. (King et al., 2013)).

**Rest-time:** Because the gaming session took for 3-hours, participants may need to get away from the chair e.g. go to the restroom. There was no restriction for using the restroom, however, participants were not allowed to move from the chair for any other situation. If a participant need to use the restroom, the rest-time will be taken. However, it was observed that all participants in the study did not get away from the chair for the whole experimental session.

#### *Experiment Procedure*

**Screening:** Participants' eligibility was checked in which he has to be a male college student who is between 18-25 years of age, with a healthy current condition at the time of the study (e.g. no sign of fever, sinus, and etc.). If the participant did not fulfil all the recruitment criteria, he will be dismissed, else, he will proceed to the next step.

**Informed Consent Form:** Before the experiment starts, a participant was briefed about the safety of the premises i.e. the fire exit, nearest fire assembly point, and the restroom. Then, a participant was asked to read this form for a better understanding of the study in general so that he can have his consent in participating in the study. Then, the experimenter briefed the participant on the important information of the form - experiment purposes in general, the task that he has to do, voluntary condition of the experimental session, confidentiality of the collected data, and the risk & benefit of the study. Then, a participant was asked to sign two copies of the form that given his consent to participate in the study. One copy was given to the participant for their reference, and the other was kept in the study's file.

**Participant Form:** Then participants' demographic information - age, and race - was obtained. After that, several questionnaires related to the study were asked to the participants. These included the participant's health and gaming experiences information.

**Corlett & Bishop's Scale Form:** A participant was asked to fill in the Corlett & Bishop's Scale for Body Symptom Survey Form, and was asked to place an 'X' at the region of body diagram that he feels any discomfort of himself at that period of time.

**Experimental Session:** For experiment control purposes, participants were asked to turn off his cell phone at all times during the experiment or hand-in it to the experimenter to monitor the

incoming calls and messages as an emergency precaution. After that, a participant was placed at the computer workstation. Then he was asked to start the gaming session.

**Corlett & Bishop's Scale Form:** Immediately after the gaming session, a participant was again asked to fill out the Corlett & Bishop's Scale for Body Symptom Survey Form, and was asked to place an 'X' at the region of body diagram that he feels any discomfort of himself at that period of time.

**Payment Voucher and Thanking Session:** A participant was asked to fill out his details and the amount of compensation received on the Payment Voucher and was paid MYR 15. Lastly, the participant was thanked for his volunteering to participant in the study.

#### *Data Scoring & Analysis Method*

##### *Trunk Posture Analysis*

Scoring method (based on RULA by McAtamney & Corlett, 1993): If the trunk position of a participant is at 0° angle, he was scored 1; > 0° to 20° was scored 2; > 20° to 60° was scored 3; and > 60° was scored 4. In addition, if a participant twisted his trunk, the score was added by 1; and if a participant was side-bent his trunk, the score was also added by 1. Thus, the possible total score for the trunk posture analysis is from 1 to 6. In scoring this analysis, a protractor was used to measure the angle of the participant's trunk position. Dependent variable: The mean value of the trunk posture score. The mean value for each data group (one-hour-data; two-hours-data, and three-hours data) was calculated and compared. Hypothesis: The mean value for the three-hours-data will be greater than the two-hours-data, and the mean value for the two-hours-data will be greater than the one-hour-data ( $\text{mean}_{3\text{-hours}} > \text{mean}_{2\text{-hour}} > \text{mean}_{1\text{-hour}}$ ). In this analysis, the more the mean score indicates the more the risk for the musculoskeletal disorders that an individual may have, resulting from his or her trunk position. This is because whenever a position of a human body is away from the neutral (or anatomical) position, the muscle which spans the joint are stretched to more possible extent, and the bone's disks are disrupted and result in greater stress (The American Academy of Orthopaedic Surgeons, 1965). This biomechanical principle was confirmed by several postural analysis tools such as Rapid Upper Limb Assessment - RULA (McAtamney & Corlett, 1993), and Rapid Entire Body Assessment - REBA (Hignett & McAtamney, 2000); as well as several guidelines for ergonomics concern at workplaces e.g. (Department of Safety & Health Malaysia, 2017). Statistical Analysis: The mean scores were calculated. From the output, a descriptive statistic graph (means score) was plotted. In

order to analyze this finding, the One-way ANOVA model was applied. This model was utilized because there are three data groups being compared (Morgan et al., 2003).

##### *Neck Posture Analysis*

Scoring method (based on RULA by McAtamney & Corlett, 1993): If the neck position of a participant is between 0°-10° angle, he was scored 1; 10° - 20° was scored 2; >20° was scored 3; and if in an extension posture he was scored 4. In addition, if a participant twisted his neck, the score was added by 1; and if a participant was side-bent his neck, the score was also added by 1. Thus, the total score for the trunk posture analysis is also from 1 to 6. In scoring this analysis, a protractor was used to measure the angle of the participant's neck position. Dependent variable: The mean value of the neck posture score. The mean value for each data group (one-hour-data; two-hours-data, and three-hours data) was calculated and compared. Hypothesis: The mean value for the three-hour-data will be greater than the two-hours-data, and the mean value for the two-hours-data will be greater than the one-hour-data ( $\text{mean}_{3\text{-hours}} > \text{mean}_{2\text{-hour}} > \text{mean}_{1\text{-hour}}$ ). In this analysis, the more the mean score indicates the more the risk for the musculoskeletal disorders that an individual may have resulting from his or her neck position. This is because whenever a position of a human body is away from the neutral (or anatomical) position, the muscle which spans the joint are stretched to more possible extent, and the bone's disks are disrupted and result in greater stress (The American Academy of Orthopaedic Surgeons, 1965). This biomechanical principle was confirmed by several postural analysis tools such as Rapid Upper Limb Assessment - RULA (McAtamney & Corlett, 1993), and Rapid Entire Body Assessment - REBA (Hignett & McAtamney, 2000); as well as several guidelines for ergonomics concern at workplaces e.g. (Department of Safety & Health Malaysia, 2017). Statistical Analysis: The mean scores were calculated. From the output, a descriptive statistic graph (means score) was plotted. In order to analyze this finding, the One-way ANOVA model was applied. This model was utilized because there are three data groups being compared (Morgan et al., 2003).

##### *Corlett & Bishop's Body Symptom Survey*

Scoring method: For each participant, the number of 'X' was counted for both pre- and post-experimental session. Then, the score which is equal to  $X_{\text{after}} - X_{\text{before}}$  and its mean was calculated. Positive score value indicates that the discomfort level of the participant increases, on the other hand, the negative score value indicates the discomfort level of the participant decreases. Zero value indicates that there is no difference in term of discomfort level of the participant in comparison of the pre- and post-



experimental session. Dependent variable: The mean value (number of 'X') of the Corlett & Bishop's Scale (i.e.  $X_{\text{after}} - X_{\text{before}}$ ). The mean value for each data group (one-hour-data, two-hours-data, and three-hours-data) was calculated and compared. Hypothesis: The mean value for the three-hours-data will be greater than the two-hours-data, and the mean value for the two-hours-data will be greater than the one-hour-data ( $\text{mean}_{3\text{-hours}} > \text{mean}_{2\text{-hour}} > \text{mean}_{1\text{-hour}}$ ). In this analysis, the more the mean score indicates the more discomfort the participant felt after finished the gaming session. This is because, prolonged sitting is known to cause a feeling of discomfort and increase the risk for musculoskeletal disorders (e.g. (Bardin, King, & Maher, 2017); (Li et al., 2017); (Coenen et al., 2017); (Sammonds, Fray, & Mansfield, 2017)). Statistical Analysis: The raw data from the experiment was transferred into the SPSS statistical package software. The data was then analyzed in order to compute the mean of the variable. From the output, a descriptive statistic graph (mean scores) was plotted. In order to analyze this finding, the One-way ANOVA model was applied. This model was utilized because there are three groups being compared (Morgan, Leech, Gloeckner, & Barrett, 2003).

## RESULTS & DISCUSSION

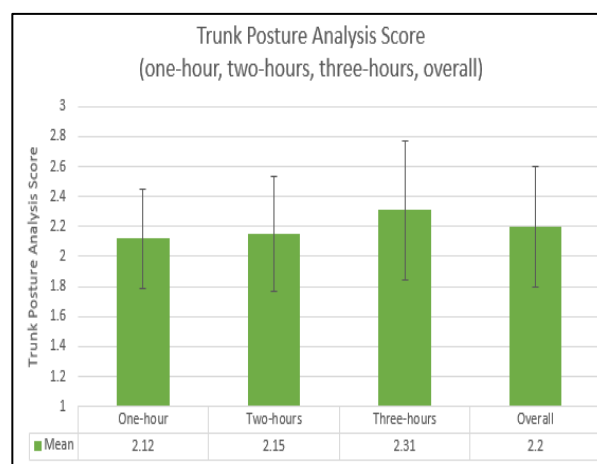
Ten participants who were IIUM students participated in this study, and their age range is from 21 to 25 years old [mean = 23.85; SD 1.16]. Even though the experiment is open to all type of races, all of them are from Malays ethnic. None of them has reported having a neck and back problem. Generally, in term of gaming experiences, they have experience in gaming for 1 to 19 years of duration [mean = 7.17; SD = 4.47]. This showed that, on average, they have started play games since adolescent years  $\approx$  16 years old [23.85 - 7.17]. In addition, they also have reported that, on average, they play games for 4.40 days per week with 3.57 hours per day. Moreover, during a week before the experiment, they have reported that, on average, they have played for 4.10 days per week with 3.43 hours per day. These show that they are active and regular gamers (King et al., 2013), which is the preferred group for the study even though it is difficult to confirm if a particular participant is a regular gamer prior the experimental session (i.e. because the participants only responded to these questions during the experimental session).

*To evaluate the effect of prolonged gaming on the trunk posture by using trunk posture analysis (measured).*

From the raw data, the average trunk posture analysis score for each one-hour-data, two-hours-data, and three-hours-data were calculated, and the graph for the averages was plotted. Figure 3 illustrates the average trunk

posture analysis score for each category and overall.

In overall, the average of trunk posture score is 2.20 [SD = 0.404]. Specifically, the mean values of the trunk posture score of one-hour-data, two-hours-data, and three-hours-data are 2.12 [SD = 0.331], 2.15 [SD = 0.383], and 2.31 [SD=0.464] respectively (the error bar in Figure 3 shows the standard deviation range of the data). The graph shows that there is an increasing pattern of the average trunk posture score from the one-hour-data to two-hours-data, and to three-hours-data.



**Fig. 3** Average trunk posture analysis score for each category and in overall

However, it can be seen from the graph that the average for the one-hour-data and two-hours-data are quite close in comparison to the three-hours-data. This means that the effect of the one-hour and two-hours period of gaming are similar, whilst the effect of three-hours of gaming is larger in comparison to one and two hours' period of gaming.

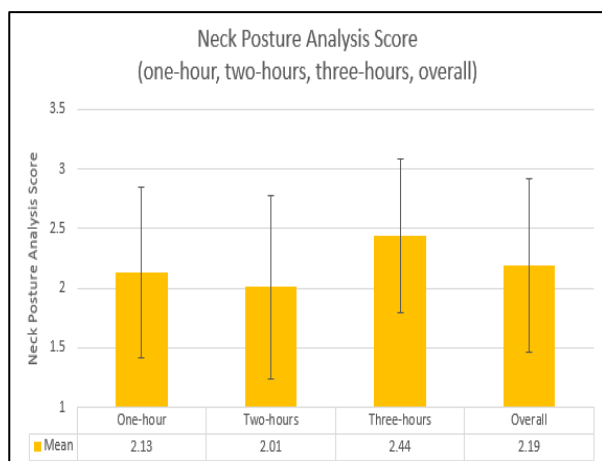
In order to check the differences, the data were transferred into the SPSS statistical software (version 23), in which the one-way ANOVA analysis model was utilized. One-way ANOVA analysis is the best model to analyze this type of data because, this data consists of only one independent variable (trunk posture analysis score), and has three dependent variables (one-hour-data, two-hours-data, and three-hours-data). One-way ANOVA is suited to be used when there is only one independent variable involves and consists of three or more dependent variables (Morgan et al., 2003). The null hypothesis is that the means values are all same ( $H_0: \mu_{\text{one-hour-data}} = \mu_{\text{two-hours-data}} = \mu_{\text{three-hours-data}}$ ), and the alternative hypothesis is that at least one mean differs from the other ( $H_a =$  at least one mean is differs from the other). Utilizing the one-way ANOVA, it was found that there was a significant effect of the duration of gaming (hourly comparison) at  $p < 0.001$  for the three

conditions [  $F(2,1077) = 23.107, p = 0.0000$ ]. Thus, the null hypothesis was rejected.

In order to investigate further, the Paired Samples t-test analysis was utilized. This particular model specifically compares the differences between two elements at a time (Morgan et al., 2003). In explanation, this analysis is to compare the following: (i) differences between one-hour-data and two-hours-data; (ii) differences between one-hour-data and three-hours-data; and (iii) differences between two-hours-data and three-hours-data. The Paired Sample t-test revealed that: (i) the mean trunk posture score of one-hour-data was lower than the two-hours-data by 0.028 but not significantly [  $t(359) = -1.066, p = 0.287$ ]; (ii) the mean trunk posture score at one-hour-data was significant lower than the three-hours-data by 0.186 [  $t(359) = -6.422, p = 0.000$ ]; and (iii) the mean trunk posture score at two-hour-data was significant lower than the three-hours-data by 0.158 [  $t(359) = -5.751, p = 0.000$ ]. This finding shows that, indeed, the effect of the one-hour and two-hours period of gaming are similar, whilst the effect of three-hours of gaming is larger in comparison to one and two hours' period of gaming.

*To evaluate the effect of prolonged gaming on the neck posture by using neck posture analysis (measured)*

From the raw data, the average neck posture analysis score for each one-hour-data, two-hours-data, and three-hours-data were calculated, and the graph for the averages was plotted. Figure 4 illustrates the average neck posture analysis score for each category and overall. In overall, the average of neck posture score is 2.19 [SD = 0.731]. Specifically, the mean values of the neck posture score of one-hour-data, two-hours-data, and three-hours-data are 2.13 [SD = 0.715], 2.01 [SD = 0.767], and 2.44 [SD=0.643] respectively (the error bar in Figure 4 shows the standard deviation range of the data).



**Fig. 4** Average neck posture analysis score for each category and in overall

The graph shows that the average neck posture score decreases a bit from one-hour-data to two-hour-data, but, increase greatly from the two-hours-data to three-hours-data. However, similarly to the average trunk posture score, it can be seen from the graph that the average for the one-hour-data and two-hours-data are quite close in comparison to the three-hours-data (only the pattern was reversed in comparison to the trunk analysis). This means that the effect of the one-hour and two-hours period of gaming are similar, whilst the effect of three-hours of gaming is larger in comparison to one and two hours' period of gaming.

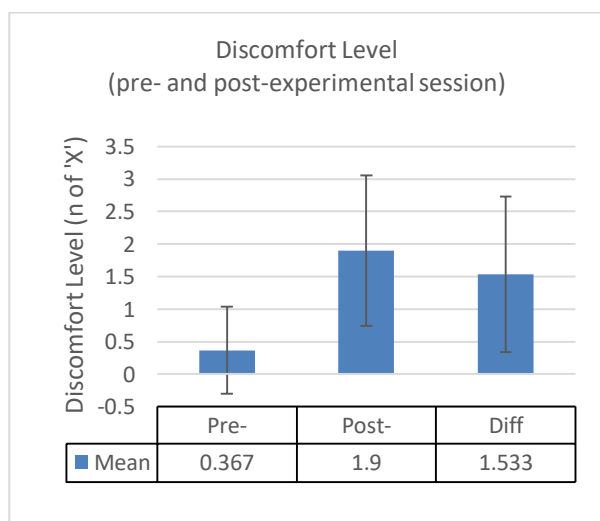
In order to check the differences, the data were transferred to the SPSS statistical software (version 23), in which the one-way ANOVA analysis model was utilized. As mentioned earlier, one-way ANOVA analysis is the best model to analyze this type of data because, this data consists of only one independent variable (neck posture analysis score), and has three dependent variables (one-hour-data, two-hours-data, and three-hours-data). One-way ANOVA is suited to be used when there is only one independent variable involves and consists of three or more dependent variables (Morgan et al., 2003). The null hypothesis is that the means values are all same ( $H_0: \mu_{\text{one-hour-data}} = \mu_{\text{two-hours-data}} = \mu_{\text{three-hours-data}}$ ), and the alternative hypothesis is that at least one mean differs from the other ( $H_a = \text{at least one mean is differs from the other}$ ). Utilizing the one-way ANOVA, it was found that there was a significant effect of the duration of gaming (hourly comparison) at  $p = 0.000$  for the three conditions [  $F(2,1077) = 33.819, p = 0.0000$ ]. Thus, the null hypothesis was rejected.

In order to investigate further, the Paired Samples t-test analysis was utilized. As mentioned earlier, this particular model specifically compares the differences between two elements at a time (Morgan et al., 2003). In explanation, this analysis is to compare the following: (i) differences between one-hour-data and two-hours-data; (ii) differences between one-hour-data and three-hours-data; and (iii) differences between two-hours-data and three-hours-data. The Paired Sample t-test revealed that: (i) the mean neck posture score of one-hour-data was higher than the two-hours-data by 0.072 but not significantly [  $t(359) = 1.592, p = 0.112$ ]; (ii) the mean neck posture score at one-hour-data was significant lower than the three-hours-data by 0.325 [  $t(359) = -6.897, p = 0.000$ ]; and (iii) the mean neck posture score at two-hour-data was significant lower than the three-hours-data by 0.397 [  $t(359) = -7.956, p = 0.000$ ]. This finding shows that, indeed, the effect of the one-hour and two-hours period of gaming are similar, whilst the effect of three-hours of

gaming is larger in comparison to one and two hours' period of gaming.

*To evaluate the discomfort level among the gamers during pre- and post-experimental session by using the Corlett & Bishop's Scale (self-reported, subjective rating)*

From the raw data, the average self-rated discomfort level among the gamers during pre- and post-experimental session by using the Corlett & Bishop's Scale were calculated, and the graph for the averages was plotted. Figure 5 illustrates the average self-rated discomfort level for pre- and post-experimental session and its difference. The mean values of the self-rated discomfort level of pre- and post-experimental are 0.37 [SD = 0.669] and 1.90 [SD = 1.155] respectively, and the difference is 1.53 [SD = 1.196] (the error bar in Figure 5 shows the standard deviation, and there is negative error bar for pre-data because 22 out of 30 participants rated themselves to have zero number of discomfort area at the beginning of the gaming session). The graph shows that, on average, participants rated their post-experimental discomfort level higher in comparison to their pre-experimental discomfort level. This means that the prolonged gaming session does affect the discomfort level among the gamers.



**Fig. 5** Average rated discomfort level for pre- and post-experimental session and its difference

In order to check the differences within group i.e. if the participants were rating their discomfort level differently during the pre- and post-experimental session differently, the data were transferred to the SPSS statistical software (version 23), in which the one-sample t-test analysis model was utilized to check this difference (Morgan et al., 2003). The results revealed that there were significant differences within the pre- [t (29) = 3.003, p = 0.005] and post- [t (29) = 9.009, p = 0.000] experimental session.

In order to investigate further, the Paired Samples t-test analysis was utilized. As mentioned earlier, this particular model specifically compares the differences between two elements at a time (Morgan et al., 2003). In explanation, this analysis is to compare differences between pre- and post-experimental session of the self-rated discomfort level of the participants. The Paired-Sample t-test revealed that the mean self-rated of the discomfort level of the pre-experimental session is significantly lower than the post-experimental session by 1.533 [t (29) = -7.023, p = 0.000]. This finding shows that, indeed, the participant felt more discomfort at the end of the experimental session in comparison to the beginning of the experimental session.

Next analysis is to check if there is any correlation among the data. In explanation, it is to investigate how often the score of discomfort level during the post-experimental session is higher than the pre-experimental session. To do this, Paired Samples Correlation was analyzed. The analysis revealed that the self-rated discomfort level during the post-experimental session is always higher the pre-experimental session with 77.8% of the time it was true but not significantly different (r = 0.772), p = 0.226. The comparison does have a strong correlation because it was above 70%. As mentioned earlier, the correlation is categorized as strong only if the R-value is > 0.7 (or 70% of the time) (Morgan et al., 2003). Table 10 is the output of the Paired Samples Correlation analysis.

## CONCLUSION

The first objective is to evaluate the effect of prolonged duration of gaming on trunk posture by using the trunk posture analysis. It was found that, in overall, the average of the trunk posture score is 2.20 [SD = 0.404]. Specifically, the mean values of the trunk posture score of one-hour-data, two-hours-data, and three-hours-data are 2.12 [SD = 0.331], 2.15 [SD = 0.383], and 2.31 [SD=0.464] respectively. Utilizing the one-way ANOVA, it was found that there was a significant effect of the duration of gaming (hourly comparison) at p = 0.000 for the three conditions [ F (2,1077) = 23.107, p = 0.0000]. In conclusion, the effect of the one-hour and two-hours period of gaming on trunk posture is similar, whilst the effect of three-hours of gaming is larger in comparison to one and two hours' period of gaming.

The second objective is to evaluate the effect of prolonged duration of gaming on neck posture by using the neck posture analysis. It was found that, in overall, the average of neck posture score is 2.19 [SD = 0.731]. Specifically, the mean values of the neck posture score of one-hour-

data, two-hours-data, and three-hours-data are 2.13 [SD = 0.715], 2.01 [SD = 0.767], and 2.44 [SD=0.643] respectively. Utilizing the one-way ANOVA, it was found that there was a significant effect of the duration of gaming (hourly comparison) at  $p = 0.000$  for the three conditions [  $F(2,1077) = 33.819$ ,  $p = 0.0000$ ]. In conclusion, the effect of the one-hour and two-hours period of gaming on neck posture is similar, whilst the effect of three-hours of gaming is larger in comparison to one and two hours' period of gaming.

The third objective is to evaluate the discomfort level among the gamers during pre- and post-experimental session by using the Corlett & Bishop's Scale (self-reported, subjective rating). It was found that, the mean values of the self-rated discomfort level of pre- and post-experimental are 0.37 [SD = 0.669] and 1.90 [SD = 1.155] respectively, and the difference is 1.53 [SD = 1.196]. The Paired-Sample t-test revealed that the mean self-rated of the discomfort level of the pre-experimental session is significantly lower than the post-experimental session by 1.533 [t (29) = -7.023,  $p = 0.000$ ].

#### *Contribution and Impact of the Study*

The results from this study provide additional information about musculoskeletal disorders in general, more particularly, on the gaming activities. Society: The findings could be used as a guideline among the gamers to limit their gaming duration for instance, to ensure to take a rest for every two hours or so as the effect was shown to be significant by the three-hours-data. Moreover, parents of adolescents also could monitor their kids (who are regular gamers) to not play PC gaming for a prolonged duration. Global: As gaming becoming one of the popular industry in the world these days, these findings could promote better strategies among the professional gamers to not play PC games for prolonged duration, or at least be more caution about the risk for musculoskeletal disorders in general, more specifically, the effect on the trunk and neck posture. Lastly, the finding from this study also could lead the other similar research studies in deeper approaches.

#### *Limitations and Recommendation*

There are several limitations were faced in developing the experimental design for the study. Firstly, the participants and premises for the experiment were preferred to be gamers at the cyber café in an assumption that they are extremely active in gaming activities. However, due to time and budget constraint, college students from the IIUM was recruited. Secondly, a better computer workstation was preferred - e.g. gaming chair, so that it mimics the real situation of the gaming industry. In addition, gaming workstation also offers an ergonomic workspace, thus, other factors that contribute to

musculoskeletal disorders such as improper workstation could be eliminated. However, precaution has been taken, in which, an adjustable chair was used throughout the study. Thirdly, a longer gaming duration would have preferred. This study required the participants to play the PC game for three hours. As the effect was started to show by the 3rd hours, it would be interesting if a longer experimenter session can be done so that, a better effect can be seen, perhaps showing an interesting pattern of the effect of prolonged gaming duration on the risk for musculoskeletal disorders.

#### *Recommendations for Future Study*

As mentioned above, a longer gaming duration would be interesting to be explored. In addition, different variables such as the effect on other parts of the human body could be investigated such as shoulder, hands, wrist, eyes, legs and so on.

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