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ORIGINAL ARTICLE

Preliminary Study of Postural Safety and Ergonomics Analysis Related to Cycling Activity

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ABSTRACT

Introduction: In cycling activity, having a good proper posture can reflect good performance and comfort of the cyclist. Incorrect posture will lead to future health problems such as back pain. On some occasions, the muscle activity of the cyclist also can be affected due to improper posture, non-ergonomic posture. Design and load can be major factors of injury as well. This preliminary study helped to identify and investigate the postural safety and ergonomic analysis of cyclist muscle activity during cycling. **Methods:** A questionnaire was used to get an overview and prior knowledge of postural safety and ergonomic of random cyclists on the university campus. Then, Surface Electromyography sEMG and postural angle from Kinovea software were used to measure and compare the results with and without load among cyclists. In this study, there was a significant effect of saddle height and pedalling on the cyclist's body posture. This showed an optimum power and effectiveness performance while cycling. This led to comfort and reduce the chance of injury such as back pain towards cyclist. **Results:** Based on the results, the lower back muscles activity pattern for cyclists with the load was higher compared to cyclists without the load (the optimum saddle height was applied). The cyclist's lower back muscles activity showed an increasing pattern overtime. **Conclusion:** Therefore, this study will be helpful to the cyclist to get awareness regarding correct posture safety and feel more comfortable when cycling. Further improvement should be taken for future enhancement of the findings.
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INTRODUCTION

Nowadays, cycling is one of the popular sports or recreational activities that can offer many potential health benefits to the cyclist. Cycling can be considered as one of the most beneficial physical activities to the whole body of the cyclist. Due to the cycling advantages, cycling has been recognized as an alternative sport or activity that encourages great public health to humans (1, 2). Thus, cycling is one of the important topics to study in many perspectives mostly related to performance, human safety and health. As cycling can give many good benefits, it also gives several drawbacks to cyclists' physical health such as muscle soreness and back pain. Therefore, study on biomechanics towards cyclists has been widely carried out by the researchers (3).

Based on the ergonomics and postural safety perspectives, one of the major concerns during cycling is ergonomic design and human body posture during cycling. There are some studies being carried out between the minimal amount of energy and specific speed used by the cyclist (4). Other than that, there are some researchers who focused on three main positions of cyclists such as upright, dropped and elbows positions to find the best position during cycling (5,6). The human body position is crucial to determine the best posture and pattern to get the most effective position. Other than that, previous research shows that the numerical simulations method is the most accurate in assessing aerodynamics (7).

During cycling, most of the lower limb body parts have been utilized to move the bicycle. Some studies also showed the position of pedal and foot give a significant effect on cyclist performance. Other study also mentioned that pedalling technique could improve the cyclists' force effectiveness and power output (8). Another study was also done by other researchers which showed that there was a performance difference between the short (4 km) and long-distance time (20 km) (9, 10).

Moreover, most of the studies were focused on the effectiveness of pedal force by the cyclist. This study showed that the workload level can be a constraint for the pedal force (11,12) while other studies discussed the effect of body position (13-16) and experience or skill of the cyclist (17,18).

However, in postural safety and ergonomic, cycling issues can be a major concern. Some injuries such as musculoskeletal disorders (MSD), back pain and many other chronic health problems may occur due to prolonged cycling. The awkward posture and prolonged flexion such as bending forward may lead to injuries such as stress exertion on the cyclist's shoulder, neck and back. This can lead to incorrect posture which caused the cyclist to feel discomfort.

Therefore, the objectives of this preliminary study were to identify the cyclist's knowledge about posture safety and ergonomic in cycling, investigate the effect of saddle height toward the postural angle of the cyclist and evaluate the muscle activity among the cyclist with and without load.

MATERIALS AND METHODS

Participants

This study was conducted using two different approaches. The first method was a subjective study, where a cross-sectional study was done among the cyclists on the university campus. The sample size in this study was 80 respondents with a confidence level of 95% and a margin error of 5%. As in this study, there were eighty-nine cyclists on the university campus (n=89) of different ages, gender, race and Body Mass Index (BMI). The respondents were randomly selected from the cyclists in the selected university campus to answer the questionnaires. This simple questionnaire was developed to identify and investigate the cyclist's knowledge and experience related to postural safety and ergonomic. For the second method, the objective study was conducted among the selected (n=10) male cyclists in this experimental study which also the respondents for subjective study. These respondents were selected randomly with consents to undergo the postural safety and ergonomic analysis. This was to evaluate the lower back muscles activity among the cyclists with two conditions of the experiment.

Instrumentations

In this study, the subjective study used a simple questionnaire that was developed to get the cyclist's feedback on postural safety and ergonomics while cycling on the campus. For the subjective study, EKEN H8R 4K was used as a camera to record the cyclist's movement during training. A bicycle speed sensor was used to ensure constant speed for all cyclists. A pulse oximeter was used to get the oxygen saturation (SpO_2) reading of the cyclist. Kinovea software was used to analyse the 2D postural angle. Surface Electromyography (sEMG) myoware sensor was used to analyse the back muscle activity of the cyclist.

Data Analysis

All data acquired from the simple questionnaire among cyclists in the selected university campus were analysed and tabulated in charts form. While for objective study, the experimental result of 10 selected cyclists for the data of oxygen saturation (SpO_2) was gathered from a pulse oximeter datasheet and was observed to be in range 90% - 95% when conducting this experiment. Meanwhile, based on the sEMG's data gathered from the myoware sensor, the signal amplitude ranged from 0 to 500 mV (peak-to-peak) was observed. The data was tabulated in the charts form using the Matlab software.

ETHICAL CLEARANCE

This study was approved by the Research Ethics Committee, The National University of Malaysia with Ref No: UKM PPI/111/8/JEP-2019-529.

RESULTS

In this preliminary study, the subjective study was conducted to gather the prior knowledge among 89 respondents that used bicycles on the campus from their college to the designated lecture hall, faculty and lab. Based on the findings, it was clearly shown that females did not cycle much than males. The data demonstrated that 69.7% were male cyclists and 30.3% were female cyclists. This was due to the female personal safety and they preferred to use shuttle bus on the campus. Meanwhile, the knowledge on correct posture showed that 52.8% of respondents did not know the correct posture while cycling.

While for show discomfort experience of cyclist, 70.8% of cyclist had experienced minor injuries and discomfort. Incorrect saddle height and handlebar height can cause the rider's weight to be poorly excessive rocking in the saddle both which can cause discomfort. This also has been discussed by other researchers where pedalling can be a major concern in the effectiveness of cyclists (8).

From the questionnaire data, more than half (52.8%) of the respondents revealed discomfort feeling in the lower back body area. Most of the cyclists experienced pain in the lower back body area. This clearly showed that back pain was very common in the cyclist and can arise from many different causes, including bike fit, personal health issues and riding style. The bad posture during cycling could cause back pain as well.

For the objective study, ten male cyclists (n=10) were selected randomly to investigate the postural condition while cycling. Table I shows the BMI information of the respondents. From table I, it can be clearly seen that the lowest BMI was 21.9 and the highest was 28.3. For the age, the eldest was 27 years old while the youngest was 20 years old.

Table I Demographic information (n=10)

Cyclist	Age (Years)	BMI
Cyclist 1	20	23.9
Cyclist 2	20	21.9
Cyclist 3	21	24,8
Cyclist 4	23	24.2
Cyclist 5	27	23.9
Cyclist 6	24	28.3
Cyclist 7	23	24.7
Cyclist 8	23	22.6
Cyclist 9	22	25.6
Cyclist 10	22	24.9

In this study, the focus was to identify and investigate the postural safety and ergonomic analysis of the cyclist. There were two types of experiments being carried out to investigate the lower back muscles' activity when cycling which was without load and with the load. Fig 1 shows the typical respondent's experiment setup.

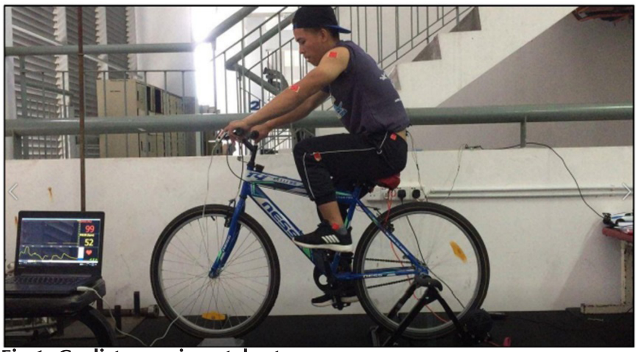

Fig 1: Cyclist experimental setup

This setup was used for both experiments without load and with the load. The cyclist was marked with marker on the cyclist body for Kinovea software analysis. The cyclist also needed to cycle with a constant speed of 20-25km/hr on a bicycle trainer for 15 minutes. The saddle height was also adjusted up to the optimal and based on the comfort of the cyclist.

In order to conduct the experiment safely, the optimal postural safety was identified based on the saddle height which depends on the cyclist height. If the saddle was too low, it could affect the lower back of the cyclist such as being tenser with the motion based on the angle of the hip which was higher than usual. If the saddle was too high, the range of motion of the ankle for the knee would be higher. Fig 2 and Fig 3 show the comparison of the postural angle being analysed with the Kinovea software.

The differences in height of the saddle gave a significant effect on the posture of the cyclist from the angle of the knee. This effect was shown in Fig 2 and Fig 3, where a high saddle required a higher knee angle up to 138o compared to the low saddle with 103o. The back posture of the cyclist also showed that the high saddle tended to show back posture which become more comfortable compared to the low saddle which showed tenser to lower back muscle and neck of the cyclist.

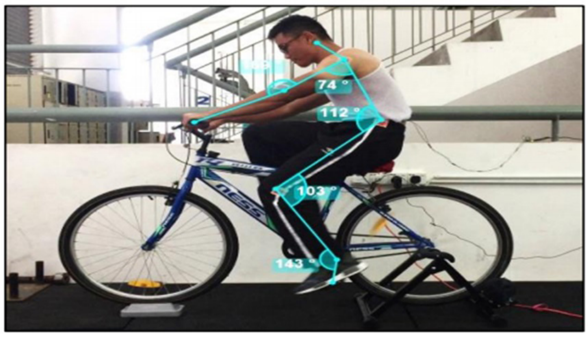

Fig 2: Low saddle height posture

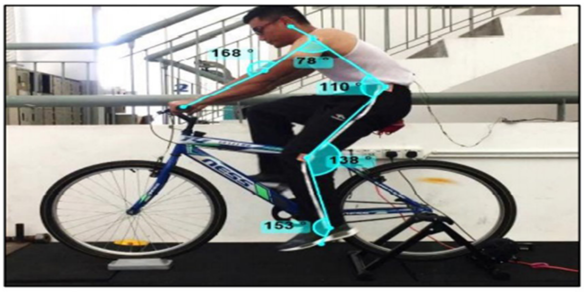

Fig 3: High saddle height posture

Without load experiment

For the case without load, the postural safety of the cyclist was determined by the muscle activity from the sEMG reading via the myoware sensor of EMG (19). The saddle height was at the optimum level for the cyclist. Fig 4 shows the cyclist posture and the sEMG signal of the lower back muscles without load. Fig 4 shows the rapid muscle activation throughout 15 minutes of cycling. The sEMG signal showed that samples of low back muscles activity were recorded and the sEMG signal was about 100mV to 200mV amplitude. This showed that the cyclist experienced less back pain while cycling without load. This also indicates that cycling without load or without using back pack had a significant effect on the lower back muscles.

With load experiment

In order to conduct the experiment with load, the cyclist was asked to use the backpack that consists of a laptop and a book with a total weight of 2.5kg. This weight was

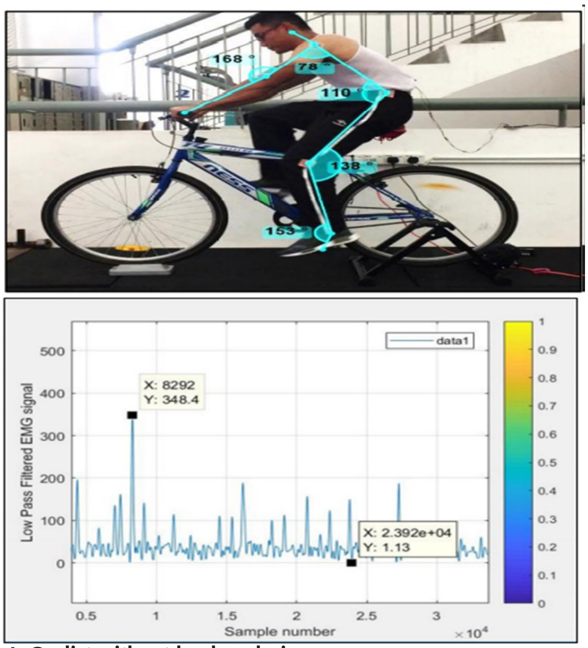

Fig 4: Cyclist without load analysis

indicated based on the findings from the questionnaire as the average weight that respondents carried while cycling. Fig 5 shows the cyclist's posture and the sEMG signal of the lower back muscles with the load on the cyclist's back.

Fig 5 shows that the cyclist's lower back muscle activation increased rapidly throughout 15 minutes of cycling. The myoware sensor was used to evaluate the lower back muscles activity of the cyclist at the lower back (20). The sEMG signal showed that the samples of lower back muscle activity were recorded with the sEMG signal from about 100mV to 300mV amplitude

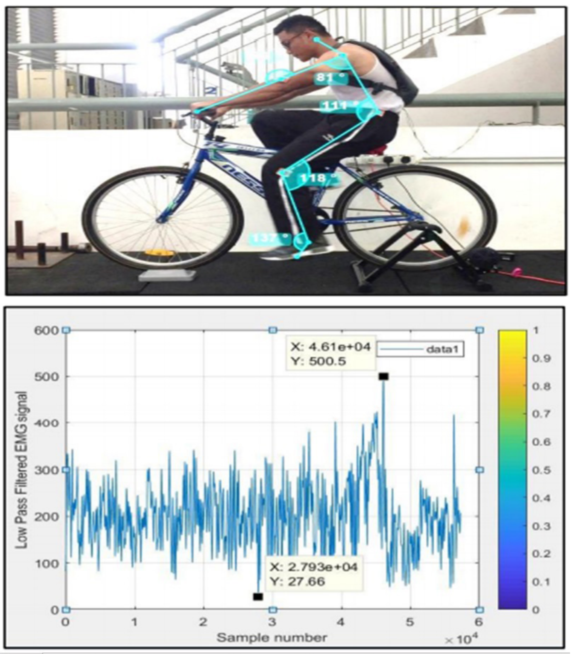

Fig 5: Cyclist with load analysis

and some samples were nearly up to 400mv amplitude. The muscle activity value in this condition was higher compared to the one without the load. In addition, the cyclists also mentioned that they experienced discomfort compared to cyclists who cycled without the load. The muscle activity value and the amplitude signal changes depend on the power given by the cyclist and number of turns related to strength of contraction from muscles (21). This indicates that cycling with the load or using a back pack has significant effects on lower back muscles. As most of the previous studies were conducted without using the load, this result could be used as a preliminary study for future research.

A previous study showed that the pedal force with a short duration time trial (4-km) cycling performance can be one of the factors that can affect the effectiveness of a cyclist (22). In this study, the respondent only cycled for 15 minutes only with a constant speed of 20-25 km/hr with an optimum saddle height to the cyclist's height. Other than that, some researchers evaluate the relationship of aerobic level of workload with the effectiveness of pedal force (23). Nevertheless, in this preliminary study, the pedal of the cyclist was set at the normal state as the respondents were students from university campus and were not athletes.

Table II shows the minimum and maximum values of the EMG signal of 10 cyclists during the experiment. The largest value of the EMG signal was 701.5mV, whereas the smallest EMG value was 128.7mV. It seems that the difference in the experimental setup can be considered as an important factor in these studies. The chosen activity was pedalled with the speed of 20 km/h to 25 km/hr for a duration of 15 minutes. To obtain a complete EMG signal from muscle activity, it can be determined during the period of muscle activity rupture of the EMG signal and simple motor response (SMR) of complete cycle (0°-360°) in cycling (21). Therefore, a complete cycle pedalling in short time can show varies muscles activation data of the cyclist.

This difference in the sEMG signal was caused by the output power such as rhythm of pedalling, level of training, workload and intensities that vary between active and non-active participants in sports (21). On the other hand, the muscle activity and coordination for single pedal cycle and between different cycles are different even for the same person (24). These factors can give a big impact upon the final result. This showed that the experiment with the load would increase the sEMG signal. If the cycling period was longer, the sEMG signal would show an increasing pattern. The time and the weight of the load also affect the sEMG signal for the lower back muscles. This study indicated that the discomfort feeling of the cyclist was usually at the lower back muscles. As a result, the posture of cycling, proper saddle height, cycling with the load and cycling without the load were the major parameters in this study.

Table II: Min. and Max. Value of sEMG Signal

	Participant	Min	Max
1	Cyclist 1	159.9	691.5
2	Cyclist 2	145.5	698.4
3	Cyclist 3	156.8	697.3
4	Cyclist 4	132.2	593.4
5	Cyclist 5	162.2	582.5
6	Cyclist 6	157.7	678.3
7	Cyclist 7	134.6	599.7
8	Cyclist 8	153.9	627.4
9	Cyclist 9	182.1	701.5
10	Cyclist 10	128.7	678.4

DISCUSSION

Based on the subjective findings, there were about 52.8% of respondents who were unfamiliar with the correct posture of cycling. This is due to the lack of information regarding postural safety and ergonomic in cycling. Most of the respondents were students, so they used bicycles on a daily basis. Other findings showed that about 70.8% of cyclists experienced discomfort and minor injury. This problem occurred due to the incorrect posture and gradient while cycling. Hug and Dorel (25) stated that pedalling via an alternate sitting and standing posture give different values in term of muscle activity. The study of EMG activity model in the muscles of lower extremities for 0% - 8% gradient was conducted by Li and Caldwell (26) and the result was later confirmed by Duc et al. (27) on posture with gradients of 4%, 7% and 10%. Most of the respondents used bicycles without knowing the correct postures such as height saddle, shoulder to handle, gradient of cycle, improper clothes and other factors. Incorrect saddle height and handlebar height actually gave negative effects to the cyclists such as experiencing discomfort at the lower back muscles. As revealed by Bini et al. (8), pedalling is one of the most important factors that needs to be controlled in order to ensure effective cycling. Therefore, in this study, the correct posture of pedalling and cyclist posture became the major concern. However, the respondent was a normal cyclist and was not an athlete. Kautz et al. and Zameziati et al. (11,12) focused on the workload relationship towards the pedal force of the cyclist.

The findings on the differences in saddle height gave a significant consequence to the cyclist. Defraeye et al. and Blocken et al. (5,6) focused on three main positions of cyclists such as upright, dropped and elbows positions in order to find the best position during cycling. However, this study focused on the back posture of the cyclist. Cyclists tended to feel more comfortable with the proper high saddle since their back posture and shoulder were in the correct position. This can give less tension to the lower back muscle and neck of the cyclist. This study showed that the saddle height was substantial towards the postural safety of a cyclist.

The current study also focused on the muscle activation at the lower back of the respondent. This study investigated different effects of cycling with and without load. As this study was carried out in the university campus, most of the respondents carried their backpacks while cycling. The backpack consisted of a laptop or books. From the results, it could be clearly shown that the sEMG signal was about 100mV up to 200mV amplitude for cycling without load, whereas the sEMG signal for cycling with load was about 200mV up to 400mV amplitude. This was due to the workload carried by cyclists which could be one of the factors for increasing muscles acting at the lower back. Kautz et al. and Zameziati et al. (11,12) showed that the workload level can be a constraint for pedal force. The workload can also be one of the factors that causes discomfort and pain at the lower back with increasing EMG signal. Erison (28) stated that EMG activity for main muscles of lower extremities when performing exercise with constant load increased at different level of intensities. The study showed that the power output of cyclists increased from 120W to 240W as it was influenced by the level of workload (28). Other than that, muscle activity also depends on the cyclist's physical condition. Candotti et al. and Sanderson et al. (17,18) mentioned that the performance of a cyclist depends on the experience or skill of using the bicycle. The active and non-active participants really showed the difference in the muscle's activity.

Therefore, these findings can encourage the researcher to discover any issues related to importance of postural safety in sports such as cycling. However, these results can be used as a preliminary study for future research. Further studies can be conducted with large number of sample size. Other than that, other variables can also be taken into account in order to get more valuable findings in this area.

CONCLUSION

This preliminary study is helpful in educating cyclists regarding ergonomic posture and safety. Having the correct posture during cycling can help cyclists to reduce the risk of injury and pain such as back pain and any other accidents that are related to health. Based on the sEMG results, it showed that cyclists would use a lot of lower back muscles activity while cycling with the presence of load. Too much load would lead to the increase in the tendency of having back pain. The proper and optimum saddle height as well as pedalling can help cyclists to get a proper posture and comfort state. This can increase the performance of cyclists and reduce the injury related to health problems. However, further study on electromyography at the back and thigh muscles can be conducted in future in order to complement the ergonomic posture analysis of cyclists. Other advanced sensors can be used in future research so as to enhance the findings of the study.

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