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Analysis of Muscle Activity in Upper and Lower Limb During Running While Holding a Phone

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Abstract

BACKGROUND: Running is one of the most well-liked forms of exercise, especially when done for recreation. Unfortunately, running is not a risk-free exercise, and one of the most common consequences of poor running habits is an increase in the frequency of injuries. One out of five recreational runners are participating with pain. Proper running biomechanics is very important to prevent injury. Yet, some runners would like hold their smartphone in their hand while they are running, which may alter their biomechanics and increase their risk of injury. **OBJECTIVE:** To find the effect of holding the mobile phone on the muscular activity of the upper and lower limb among recreational runners while running. **METHODS:** 30 male recreational runners of age ranging from 20 to 26 years were chosen as study group. Muscle activity of upper and lower limb were assessed with and without holding the smartphone while running. **OUTCOME MEASURES:** Muscle activity were measured by Surface Electromyography (SEMG). **RESULTS:** Statistical analysis was done by using paired sample 't' test, which showed high difference in upper limb muscle activity and less difference in lower limb muscle activity. **CONCLUSION:** Hence, holding a smartphone while running results in increased muscular activity in the upper limb.

Keywords: Recreational runners, Running Biomechanics, Surface Electromyography, Smartphone, Treadmill.

1. Introduction

Running is a popular activity that is practiced by lot of people from recreational fitness enthusiasts to professional athletes.[1] Its widespread acceptance due to a number of factors, including the low cost and simplicity of utilizing the required equipment, as well as the physical, mental, and social health advantages of practicing it. As a result, many people have started to run in an effort to maintain and improve their physical condition. Despite all of its advantages, recreational runners still face a high risk of injury. According to a study by Jonatan Jungmalm (2021), 46% of recreational runners sustain injuries as a result of running over the course of a year.[2] Although the majority of research focuses on lower limb biomechanics while running, upper limb biomechanics is equally important. It has been proposed that stability and balance during human locomotion are related to the swinging action of the arms. According to Arellano and Kram (2011), running without swinging the arms increases metabolic cost and compromises lateral balance, which may lead to greater muscle activity and energy consumption.[3] The prevalence of smartphones is high and the recreational runners frequently carry numerous objects in their hands while they run, including a phone or a water bottle.[4] Vincent, et al (2018) investigated the kinematic effects of running with multiple handheld water bottles in the right hand.[5] Running with a unilateral limitation on arm swing motion leads to differences in lower - limb mechanics that are not comparable to running with a bilateral restriction on arm swing motion. Running with only one arm free alters anterior plane kinematics, which has been associated with a higher risk of knee injury.[6] According to Sanchis, et al (2021), running while holding a water bottle and a mobile phone increases the dominant leg's acceleration rate moderately. The key finding was that, holding a phone or a bottle of water while running enhanced the tibia acceleration rate in the dominant leg compared to jogging with no added weight.[7] Therefore, the study aimed to examine the effect of holding a mobile phone on the muscular activity of the upper and lower limbs while running. By understanding muscle activity, this research may help to identify whether holding the objects can cause running injuries in recreational runners or not.

2. Materials and Methodology

This study employed a cross-sectional experimental design to investigate the effect of holding a mobile phone on upper and lower limb muscle activity during running. A quantitative research approach was adopted. Demographic information, including age, height, weight, body mass index (BMI), running frequency, and injury history, was collected using a structured questionnaire. Surface electromyography (sEMG) was used to assess the activity of selected upper and lower limb muscles during running under two experimental conditions: with and without holding a mobile phone. All measurements were obtained during a single testing session.

Figure 1: Placement of Electrodes

A purposive sampling method was employed to recruit recreational runners who met the eligibility criteria and were willing to participate in the study. A total of 30 participants were included. The study protocol was approved by the Institutional Ethics Committee, and all participants provided written informed consent prior to participation

The inclusion criteria comprised healthy male recreational runners aged 20–26 years, with a normal body mass index (BMI: 18.5–22.9 kg/m^2), who engaged in running at least 3–5 times per week and provided written informed consent. Participants were excluded if they had a history of neuromuscular, musculoskeletal, or cardiovascular disorders, sustained any lower or upper limb injury within the previous six months, were classified as obese, were actively involved in other structured fitness or sports training programs, or were unable to complete the study protocol.

Following participant recruitment, a physiotherapy assessment was conducted to collect demographic and clinical information, including age, occupation, history of previous injury, body mass index (BMI), hand dominance, and the number of running sessions performed per week. Prior to data collection, participants completed their usual warm-up routine, consisting of stretching exercises, jogging, and treadmill running at a self-selected pace. Surface electromyography (sEMG) was used to record muscle activity using the BIOTECH–NEUROCARE™ 2000 system. Muscle activity was quantified using amplitude values expressed in microvolts (μV).

Electrode placement was performed according to the recommendations of the SENIAM (Surface Electromyography for the Non-Invasive Assessment of Muscles) guidelines.[8] The skin at each electrode site was cleaned using alcohol swabs prior to electrode application to minimize skin impedance. Surface electrodes were positioned parallel to the muscle fiber orientation and secured using adhesive tape.

Following electrode placement, participants performed familiarization trials on the treadmill. Subsequently, each participant ran on a treadmill at a speed of 3.8 m/s for 2 min, consistent with protocols used in previous running biomechanics studies (Mercer et al., 2003)[9]. The subjects tested under two experimental conditions: (1) running while holding a mobile phone and (2) running without holding a mobile phone. A standardized non-functional smartphone model weighing 178.8 g was used for all participants. During the phone-holding condition, participants were instructed to hold the smartphone in their dominant hand.

Upper limb muscle activity was assessed first, followed by lower limb muscle activity. A rest interval of 15 minutes was provided between assessments to minimize the effects of fatigue. The muscles selected for analysis were identified from previous literature as being actively involved during running.[10] The upper limb muscles analyzed included the Anterior Deltoid, Biceps Brachii, Upper Trapezius, Brachioradialis, and Flexor Pollicis Longus. The lower limb muscles analysed included the Biceps Femoris, Rectus Femoris, Soleus, Tibialis Anterior, and Medial Gastrocnemius.

3. Results

The collected data were tabulated and analyzed using IBM SPSS Statistics for Windows, Version 25.0 (IBM Corp). Descriptive statistics were used to summarize the demographic characteristics of the participants. The amplitude (AMP) of the upper and lower limb muscles during running under two conditions with holding a mobile phone and without holding a mobile phone was analyzed. Since the same participants were assessed under both conditions, the muscle activity data were compared using a paired-samples t-test.

The demographic characteristics of the participants are presented in Table 1. A total of 30 healthy male recreational runners participated in the study. The mean age of the participants was 22.16 ± 1.74 years, with ages ranging from 20 to 26 years. The mean body weight and height were 54.26 ± 5.96 kg and 163.05 ± 8.50 cm, respectively. The participants had a mean body mass index (BMI) of 20.38 ± 1.19 kg/m^2, indicating a normal weight status. On average, participants reported engaging in running activities 4.33 ± 1.09 days per week.

Variable	**Minimum**	**Maximum**	**Mean ± SD**
Age (years)	20.00	26.00	22.16 ± 1.74
Weight (kg)	45.00	69.00	54.26 ± 5.96
Height (cm)	146.30	176.80	163.05 ± 8.50
Body Mass Index (kg/m^2)	18.20	22.90	20.38 ± 1.19
Running Frequency (days/week)	3.00	6.00	4.33 ± 1.09

Table 1. Demographic Characteristics of the Participants (N = 30)

In upper limb analyses, the Flexor Pollicis Longus demonstrated the largest increase in muscle activity, with a mean difference of 61.77 µV, followed by the Brachioradialis (43.50 µV) and Biceps Brachii (32.64 µV). Comparatively smaller, yet statistically significant, increases were observed in the Anterior Deltoid (13.19 µV) and Upper Trapezius (12.88 µV). These findings indicate that holding a mobile phone while running significantly increases upper limb muscle activation, particularly in muscles involved in grip maintenance and upper extremity stabilization.

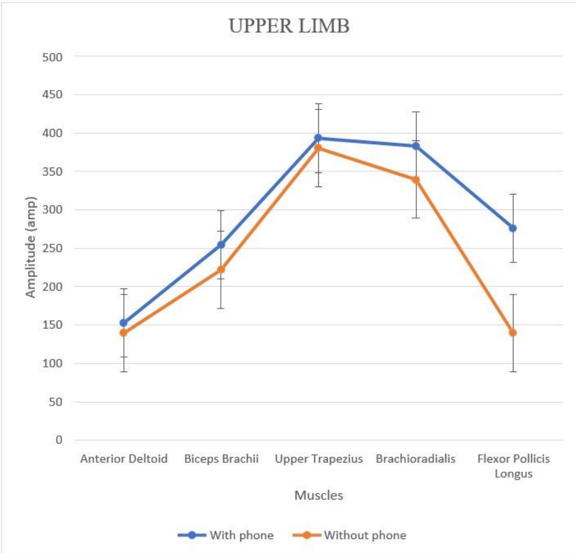

Figure 2: Upper limb muscles analysis

In lower limb analyses, the Medial Gastrocnemius demonstrated the largest mean difference (1.77 µV), followed by the Rectus Femoris (1.53 µV) and Tibialis Anterior (1.13 µV). The greater mean muscle activity was observed during the phone-holding condition but the magnitude of these differences was small, with mean differences ranging from 0.49 to 1.77 µV. However, none of these differences reached statistical significance. These findings suggest that holding a mobile phone while running does not significantly influence lower limb as the muscle activation patterns remains same with and without holding the mobile phone.

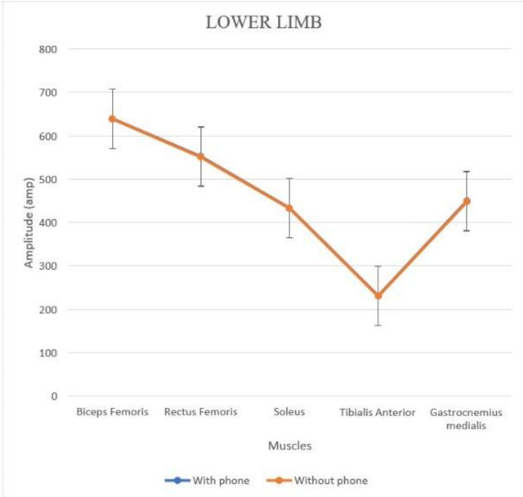

Figure 3: Lower limb muscles analysis

4. Discussion

The present study investigated the effect of holding a mobile phone on upper and lower limb muscle activity during running among recreational runners. The findings demonstrated that holding a mobile phone significantly increased the activity of the upper limb muscles, namely the Anterior Deltoid, Biceps Brachii, Upper Trapezius, Brachioradialis, and Flexor Pollicis Longus. In contrast, no significant differences were observed in the activity of the lower limb muscles, including the Biceps Femoris, Rectus Femoris, Soleus, Tibialis Anterior, and Medial Gastrocnemius.

A total of 30 healthy male recreational runners aged 20–26 years participated in the study. Female runners were not included due to known sex-related differences in running biomechanics. Previous research has reported that female runners demonstrate greater hip flexion, hip adduction, and hip internal rotation angles, as well as lower knee flexion angles compared with male runners, which may influence running mechanics and muscle activation patterns.[11] Therefore, the inclusion of only male participants helped maintain sample homogeneity and reduce potential biomechanical variability.

The increased activation of the upper limb muscles observed in the present study may be attributed to the requirement of maintaining a static grip on the mobile phone while running. Holding the device likely altered the natural arm swing pattern and increased the demand on muscles responsible for shoulder stabilization, elbow flexion, and grip maintenance. Among the muscles examined, the Flexor Pollicis Longus demonstrated the greatest increase in muscle activity, indicating the additional muscular effort required to maintain thumb flexion and secure the mobile phone during running. Similarly, substantial increases in the activity of the Brachioradialis and Biceps Brachii suggest increased demands on forearm and elbow stabilizing muscles.

The findings of the present study are consistent with previous investigations examining the effects of carrying handheld objects during running. Vincent et al. reported increased elbow flexion excursion during running while carrying a handheld water bottle, suggesting that upper limb posture and muscle recruitment are altered when an external object is carried.[5] The current findings further support the notion that even relatively lightweight handheld devices can increase upper extremity muscular demands during running.

In contrast, no significant differences were observed in lower limb muscle activity between the phone-holding and no-phone conditions. Although minor increases in muscle activation were noted, these changes were not statistically significant. This suggests that the additional load imposed by holding a smartphone is insufficient to substantially alter lower limb muscle recruitment patterns during treadmill running. While Agresta et al. reported that restricted arm swing can influence lower extremity kinematics and potentially increase injury-related biomechanical factors[12], but the smartphone used in the present study weighed only 178.8 g and did not significantly restrict arm movement. Consequently, the influence of phone holding appears to be primarily localized to the upper extremity.

The findings of this study have practical implications for recreational runners who frequently use mobile phones for music playback, fitness tracking, or communication while running. Although holding a mobile phone may not significantly affect lower limb muscle activity, the increased activation of upper limb muscles may contribute to muscular fatigue during prolonged running sessions. Repeated exposure over extended periods may potentially influence upper extremity comfort, running efficiency, or movement patterns.

Several limitations should be considered when interpreting the findings. First, the study included only male recreational runners, limiting the generalizability of the results to female runners. Second, the study was conducted on a treadmill, which may not fully replicate the biomechanical demands of overground running. Third, only the immediate effects of holding a mobile phone were investigated; the long-term consequences of repeated smartphone use during running remain unknown. Finally, the relatively small sample size may limit the generalizability of the findings.

Future studies should include larger and more diverse populations, including female runners and competitive athletes. Investigations involving over ground running conditions and different handheld objects, such as water bottles or weighted devices, may provide further insight into the influence of external loads on running biomechanics and muscle activation patterns. Additionally, longitudinal studies are warranted to examine the long-term effects of handheld device use during running.

5. Conclusion

The present study demonstrated that holding a mobile phone while running significantly increases the activity of upper limb muscles, In contrast, no significant differences were observed in lower limb muscle activity between the phone-holding and no-phone conditions.

These findings suggest that holding a mobile phone during running increases the muscular demand of the upper extremity without substantially altering lower limb muscle activation patterns. The effects of smartphone holding during running therefore appear to be primarily confined to the upper limb musculature.

Thereby, it is important to consider the positioning of upper limb during the assessment of running injuries. In case of upper limb pain, the runners are also advised not to hold any object while running which will reduce the muscle activity and thereby restoring the natural swing of the arm.

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Declaration of Conflicting Interests

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