Applied Ergonomics 74 (2019) 172–176

Contents lists available at ScienceDirect

Applied Ergonomics

journal homepage: www.elsevier.com/locate/apergo

Height adjustments on backpack-carrying systems and muscle activity

S. Kratzenstein[a,*], M. Wanstrath[b], K. Behrenbruch[c]

[a] Institute of Sport Science, Christian-Albrechts-University of Kiel, Germany
[b] Institute for Movement Science, University of Hamburg, Germany
[c] HFPS Humanergonomics UG, Fraunhoferstrasse 13, 24118, Kiel, Germany

ARTICLE INFO

Keywords:
Electromyography
Height adjustment
Carriage system

ABSTRACT

The aim of this study is to investigate the neuromuscular response of shoulder muscles at different attachment heights of a carrying system during arm movement. It was hypothesized that (1) different height adjustments lead to changes in muscle activity and (2) the shoulder horizontal provides a benchmark for the optimal attachment height of the shoulder belts. The musculus deltoideus was significantly relieved after the elevation of the shoulder belt for subjects with an initial attachment height of 2 cm below the shoulder. The musculus trapezius was relieved with the elevation above the shoulder. At a height of more than 2 cm above the shoulder, no further muscle unloading was achieved. These findings prove that a height adjustment can provide a systematic unloading or deloading of the shoulder musculature. Despite the fact that the magnitude and direction of changes in muscle activity lead to rather individual responses, the intra-individual responses are consistent. Therefore, support systems should provide the range of individual requirements.

1. Introduction

In fire service and mine rescue carriage systems are usually used to carry heavy loads (> 10 kg) such as e.g. closed circuit breathing systems. Insufficient wearing comfort during prolonged carriage can lead to the development of muscle injuries (including supportive tissue), such as shoulder traction injury and rheumatic diseases (Kuorinka and Koskinen, 1979; Anderson, 1984; Knapik et al., 1996; Westgaard, 1988). Thus, efforts need to be undertaken to provide the optimal fit of the device to the task and the specific requirements for anthropometry (Gemperle et al., 1998). These requirements include the distribution of the load on the appropriate muscles and at the same time ensure the control of the operator.

Support systems must connect a rigid framework to the flexible human body. Some criteria for designing this interface have been evaluated in numerous studies. It is confirmed that the use of a hip belt distributes a part of the load from the shoulders to the pelvis (Golriz and Walker, 2012). Although there are no uniform recommendations for the optimal position of the load along the longitudinal axis of the body, it appears that the height depends on the intended use (Bobet and Norman, 1984; Brackley et al., 2009; Stuempfle et al., 2004; Macias et al., 2008). Furthermore, the maximal load is dependent on the target group (Hadid et al., 2012; Al-Khabbaz et al., 2008; Goh et al., 1998). Despite these well investigated design and application criteria, the use of height adjustments might also determine the level of comfort. However, there is currently no research on the effectiveness of existing systems.

By using a hip belt, height adjustments should relief the shoulder muscles. While the hip belt remains stationary on the pelvis in most technical developments, a loading or unloading of the shoulders can be achieved by a stepwise adjustment of the attachment height of the shoulder belt. As a result, the shoulder belt can be attached below, above or at the same level as the shoulder horizontal. An examination of the optimal connection height with respect to the flexibility of the shoulder and arm segments is missing so far. For this study it was assumed that an attachment below the shoulder leads to an increased freedom of arm movements. The required flexibility can be taken from the material of the shoulder strap. This gain in freedom of movement, however, goes hand in hand with a higher vertical load on the shoulders. A connection above the shoulder horizontal is assumed to lead to the opposite. While the shoulder is partially fully relieved, the rotation around the longitudinal axis of the body is clearly restricted. However, it remains unclear whether the direct connection to the shoulder horizontal offers the optimal balance between the freedom of arm movement and shoulder load.

The analysis of myo-electrical signals has been proven to be a powerful to evaluate carrying comfort. Although it can not cover the whole range of factors that influence the wearing comfort (Vink, 2005),

* Corresponding author. Olshausenstrasse 74, 24098, Kiel, Germany.
E-mail address: stefan.kratzenstein@email.uni-kiel.de (S. Kratzenstein).

https://doi.org/10.1016/j.apergo.2018.08.022
Received 24 October 2017; Received in revised form 16 May 2018; Accepted 29 August 2018
0003-6870/ © 2018 Elsevier Ltd. All rights reserved.

it provides an objective insight into physiological responses to controlled changes. Previous studies investigated the neuromuscular response to changes of design features, such as weight, belt strength or the centre of gravity (Simpson et al., 2011; Holewijn, 1990). Neuromuscular fatigue when carrying different weights has been analyzed by e.g. Piscione and Gamet (2006) and Southard and Mirka (2007). Only Varghese et al. (2014) investigated the freedom of arm movements assessed by the neuromuscular signals. Since this study focused on the reliability of the set-up, there was no gain in knowledge about the influence of sizing the device. However, intra-class correlation coefficients of > 0.81 (standard error of measurement < 4%) were found to be appropriate for flexion and extension exercises of the m. deltoideus (middle) and the m. trapezius (descendence).

The aim of this study was to investigate the neuromuscular response to a mechanical height adjustment of a carrying system when moving the arms. It was hypothesized (1) that different height adjustments lead to changes in the muscle activity and (2) that the shoulder horizontal provides a benchmark for the optimal attachment height of the shoulder belts.

2. Method

2.1. Participants

23 male subjects (age 25.6 ± 5.1 years; weight 79.4 ± 11.0 kg; height 181.4 ± 9.1 cm; torso length 49.6 ± 5.9 cm; all right handed) participated in this study. The inclusion criteria were adapted to the common profile of firefighters and comprises healthy male subjects aged 18–45 years. Exclusion criteria included subjects with professional experience in the postural, extensive wearing of heavy equipment and subjects with musculo-skeletal injuries or complaints in the back, neck and arm area. The study was approved by the local ethics committee at the Institute of Sport Science at Kiel University. Prior to the study, all subjects were informed about the risks and gave their written consents to participate in this study.

2.2. Study protocol

Subjects were positioned upright standing in front of a target construction (see Fig. 2). The targets for arm reaching tasks were adjusted to each subject's anthropometrics. The basic position was defined as just standing with hanging arms (0°). Target (1) was reached by the fingertips when the subject's arm was stretched 90° posterior with the elbow slightly flexed and straight fingers. Target (2) was reached when the arm was lifted 135° with the elbow slightly bent and straight fingers. In order to reach goal (3), the test person had to reach across the body. All targets are shown in Fig. 1.The hip and the upper body were not allowed to rotate. The height of the target was defined as the difference between the shoulder height and the upper arm length. All movements were conducted with the right arm. The set of exercises included 10 repetitions of reaching each target starting from the basic position. Movement velocity was defined at 46 movements per minute and controlled by a metronome. Sets were repeated for each of three devices' adjustment heights. The hip belt was kept closed and maintained at the same position during the change of shoulder belt height. Only the shoulder belts were released and then tied back to the individual level comfort.

The carriage system (Dräger, PSS 7000) was equipped with a customized dummy of a breathing gas bottle with a total weight of 11.5 kg. Over all subjects, this corresponded to a relative weight of 15 ± 2% Bodyweight. The system allowed 3 height adjustments (S, M and L) with steps of 5 cm in between the steps. The distance between the middle of the hip belt and the attachment height of the shoulder belt at the backplate for size S was 40 cm. The distance between the attachment points of the two shoulder belts at the backplate was 15 cm. The width of the shoulder belt padding was 8 cm. All subjects wore a T-shirt underneath the device.

In order to enable further investigations of the role of the shoulder horizontal, participants were divided into three subgroups. The criterion was the relative height of the shoulder belt to the shoulder horizontal at the device setting height M. The following criteria were established: initial height of should belt attachment (1) is > 2 cm *below* the shoulder horizontal (n = 12), (2) corresponds to ± 2 cm of the horizontal (n = 7) and (3) is > 2 cm above the horizontal (n = 4).

2.3. Electromyography

Muscle activity was measured from the *m. deltoideus anterior* (DEA) and the *m. trapezius descendence* (TRD). The myo-electrical signal was derived bipolar. Skin preparation involved sanding the dry skin and cleaning with alcohol. Electrodes (Ag/AgCl, Ambu, blue sensor N, inter-electrode distance 20 mm) were placed according to the recommendations of the Surface Electromyography for the Non-Invasive Assessment of Muscles (SENIAM) projects (Hermens et al., 2000). The electrodes position at the DEA was defined at finger width distal and anterior to the acromion. The orientation was the line between the acromion and the thumb. Electrodes at the TRD were placed at 50% on the line from the acromion to the spine on vertebra C7. The orientation corresponded

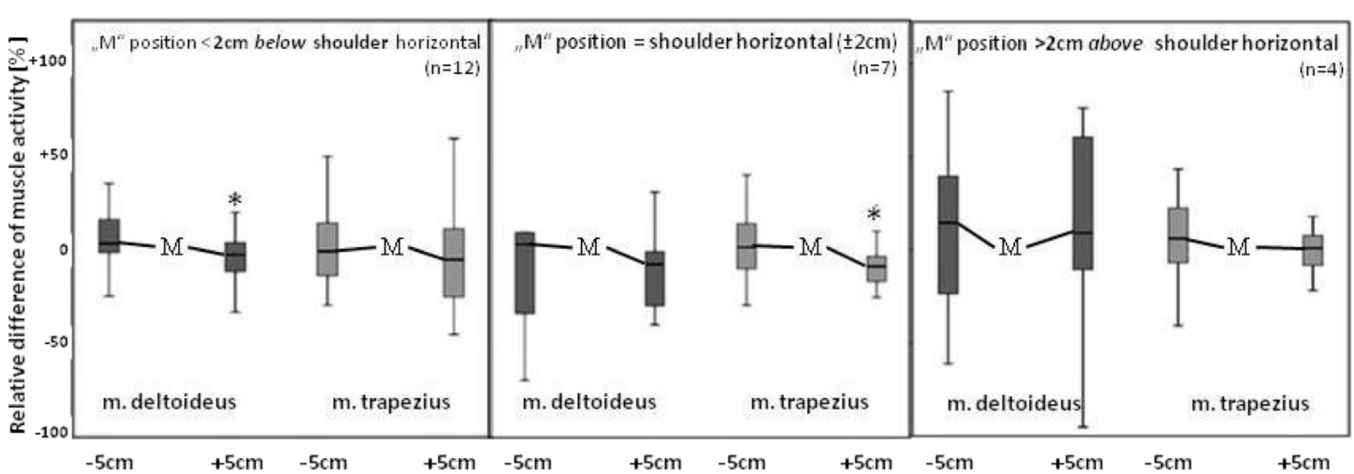

Fig. 2. Relative changes of the muscular activity after height adjustment, initially changing from size M. Subjects were grouped according to their initial attachment height relative to the shoulder horizontal. From left graphs to right: (1) Initial height at least 2 cm below, (2) ± 2 cm overlap and (3) at least 2 cm above shoulder horizontal.

Download English Version:

https://daneshyari.com/en/article/11002919

Download Persian Version:

https://daneshyari.com/article/11002919

Daneshyari.com