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Initial Subjective Load Carriage Injury Data Collected by Interviews and Questionnaires

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Abstract

This study aims to identify the types, incidence and causes of any potential load carriage injuries or discomfort, as a result of a 2 hour forced-speed treadmill march carrying 20 kg. Subjective load carriage data were collected by both interviews and questionnaires from relatively inexperienced soldiers after a period of load carriage. Results from the study showed that the upper limb is very susceptible to short-term discomfort whereas the lower limb is not. The shoulders were rated significantly more uncomfortable then any other region and blisters were experienced by around 60% of participants. Shoulder discomfort commences almost as soon as the load is added and increases steadily with time; however, foot discomfort increases more rapidly once the discomfort materialises. In conclusion, early development of shoulder pain or blisters may be a risk factor for severe pain or non-completion of a period of prolonged load carriage.

Introduction

Injury rates in the military are of great interest to all involved from regiment commanders to political decision makers all the way down to the lowest ranked soldier. Injuries in the military have been termed a hidden epidemic and are now recognised as the leading health problem for the military services[1]. For this reason it is puzzling why it has taken so long for it to be considered an important issue with this lack of research in stark contrast to the efforts made in the 1940’s with disease control[2]. More military personnel are killed, disabled or hospitalised due to injuries than any other cause. Data from the first Gulf War suggests that musculoskeletal injuries accounted for 39% of all hospital admissions, compared with only 5% that were battle-related.[3] Also, it has been suggested that between 30 – 50% of disability cases may be due to injury, with lower back pain and knee conditions being the leading cause for lifetime compensation.[4] Despite these clear implications injuries caused as a result of carrying loads have not been researched to any great depth, instead research has focused on the effects of training and identifying risk factors for injury.

To assess the incidence and prevalence of load carriage related injuries many methods can be used, these include: questionnaires, focus groups, diary studies, literature searches, interviews, risk assessments and lab based studies. For the most complete analysis both qualitative and quantitative data should be collected. Qualitative data, as collected through interviews are richer in detail and not as rigid in structure. Quantitative data, collected via questionnaires are a good way to sample a large number of participants with minimal time restraints.

Methods

Participants

Two separate groups of participants were used for the interview and questionnaire studies (table 1). The interviews were conducted with 8 members of the 1st Regiment Black Watch at Warminster, UK from the 2nd – 5th November 2004. Due to the military commitment of the UK in the Middle East soldiers present were of younger age with little operational experience. The questionnaire was completed by 10 members of the East Midlands Universities Officer Training Corps (OTC) between 17th – 31st March 2005 at Loughborough University, UK. Both groups of participants completed the same protocol.

Insert Table 1 here

Protocol

Data were collected after participants completed a 2 hour force-speed (1.61 $m.s^{-1}$) treadmill march whilst carrying 20 kg. Load was carried in either a Standard Load Carriage System (LCS) consisting of a short back standard issue ‘90 Pattern Bergen and PLCE waist webbing, or using the AirMesh LCS which consisted of AirMesh Prototype III backpack (which has functional hip belt and improved thermoregulatory qualities) and PLCE vest webbing. An unloaded SA80 assault rifle was also carried. Participants conducted the trial with both the standard and AirMesh LCS and the order of which was randomised. The interviews and questionnaires were completed after the second trial. Throughout the trial comfort ratings were taken every 15 minutes at the shoulders/neck, back, hips, feet and the thigh (used as a control), participants were asked to rate their comfort out of 5, (table 2).

Insert Table 2 here

Methods of data collection

A semi-structured interview technique was adopted. This used a small number of set questions which influence the focus of questioning allowing interesting issues raised to be explored further. Mainly open questions were asked with closed questions used to clarify or obtain definitive answers. The interview focus was derived from research questions developed from reading the literature and also by reviewing the overall aims of the study. This initial list of questions were refined and piloted until the final draft was developed. On average the interviews lasted 25 minutes and were conducted in a private room.

The questionnaire consisted of 27 questions split into 7 categories: general, upper limb, lower limb, blisters, packs, boots and other. The questions were derived from previous work reviewing the literature and interviews which had already been conducted. The questionnaire was written then edited and piloted on members of the OTC to ensure correct use of terminology and that questions were easy to understand and answer. Non-parametric statistical tests were conducted on some of the questionnaire data and significance was accepted at $p \leq 0.05$.

Results and Discussion

For this analysis only data directly related to injury or discomfort will be discussed, other data from packs, boots and cognitive testing will be excluded. This data can only determine incidence of injury for this particular group of participants, who are of relatively young age with little operational experience. However, this may give an indication to the problems experienced by new recruits or trainees.

Answers to Questions Regarding the Upper Limb

Reviewing results from the questionnaire study showed that 9 out of the 10 participants experienced discomfort to some degree in the upper limb. The most common site for discomfort were the shoulders with all participants (who reported discomfort) rating them as slightly uncomfortable or above (table 2). The second most common site was the neck with 5 from 9, then the arms/hands and upper back with 2 complaints each. Figure 1 shows the most common sites for upper limb discomfort, with the shoulders being cited significantly more times than any other region.

Insert Figure 1 here

As well as being asked to locate discomfort, the participants were asked to rate the discomfort they felt using the scale in table 2. These ratings confirmed that the shoulders are an area for concern as the discomfort ratings were significantly higher than for any other region of the upper limb, figure 2.

Insert Figure 2 here

All participants were then asked if the pain they felt during the trial was typical of that whilst carrying loads outside of the lab setting. All nine who stated shoulder discomfort said this was very typical of load carriage, again this may be a cause for concern. Four of the 5 participants who experienced neck discomfort said this was typical of carrying loads, with 1/2 for the arms/hands and 2/2 for the upper back.

Every participant questioned during the interviews rated shoulder discomfort as uncomfortable, with 50% saying shoulder pain was extremely uncomfortable (5 out of 5). Two participants who did not complete the trial attributed this to shoulder and neck pain. Again all of the participants commented that the uncomfortable feeling in the shoulders whilst carrying loads was very typical.

The questionnaire then asked how long after the load has been removed it takes for the discomfort to disappear. Answers ranged from straight away to 24 hours. The most popular response was 0 – 30 minutes, as given by 4 participants. This is in agreement with data collected from the interviews that suggests shoulder pain disappears within ½ to 3 hours after the removal of load. Although this discomfort dissipates fairly rapidly the time immediately after the doffing of a Bergen may be a time in which a soldier is engaged in combat or needs to be operating at full effectiveness.

Figure 3 shows the mean shoulder discomfort rating over time for all participants who took part in the interview study; the graph exhibits a steady increase in shoulder discomfort until around 75 minutes. After this a drop in comfort ratings is seen followed by a less steep increase. The drop in ratings seen is due to those participants who were experiencing the most severe shoulder pain retiring from the trial and therefore their data is not represented from after they withdrew. Figure 3 also shows the mean shoulder discomfort for those who completed the trial, these participants show a steady increase with time until the last 15 minutes where a slight plateau is observed. Both graphs show an almost instantaneous increase in shoulder discomfort.

Insert Figure 3 here

Another questionnaire question asked participants to highlight which of the following they feel would most increase the discomfort in the upper limb during the trial: an increase in load, distance, time, speed or other factors. The most common response was load with 7, second was distance with 6, both speed and time were third with 5. Three participants thought that all factors would increase discomfort with one participant adding terrain type or gradient. All options received an even response and highlights the multifaceted problems and inevitable discomfort of load carriage.

During the interviews after the completion of the trial many participants spoke freely about issues relating to upper limb discomfort during load carriage. Participant 8 believed the pain he felt between his shoulder blades whilst carrying the standard LCS was due to the forced contraction of the back muscles in order to keep the load closer to his body. Participant 3 remarked carrying loads caused occasional back pain and believed this was due to poor load distribution either in the Bergen or webbing. Participant 9 withdrew from both the Standard and AirMesh LCS trial with shoulder and neck pain rating 5+. The injury left him in severe pain and was a result of a previous injury sustained before joining the Army. Load carriage considerably worsened the shoulder discomfort he felt, and was typical but only when carrying loads. Another problem noted by a minority of participants was the cutting in of the vest webbing around the neck when carrying the AirMesh LCS. This caused very severe skin soreness and inflammation; one participant was forced to withdraw as this pain was too great. This highlights the need for LCS to be viewed as a single piece of equipment as one aspect of the system may cause discomfort even if the other is alleviating other potential problems.

Shoulder and neck pain can be very debilitating. Pressure placed on the soft tissue of the shoulder and neck can lead to trapped nerves or reduced blood supply to the arm and hands, this in turn may cause sensory loss in the hands or failure to fully abduct the arm which will affect the ability to aim and shoot the rifle. Other effects of load carriage are musculoskeletal neck pain caused by the forced forward head posture, or soft tissue damage, tenderness and skin irritations caused by the straps. The injuries mentioned above are mainly short-term and symptoms will probably alleviate with time and rest from load carriage; a longer-term effect may be Rucksack Palsy. Rucksack palsy is when the shoulder straps of the LCS cause a traction injury to the brachial plexus. Symptoms may include numbness in hands after the LCS is removed, paralysis or cramping of the arm and scapular winging. These data support the design goal of supporting LCS from the hips as far as possible, so as to relieve the shoulders and minimise the effects mentioned here.

Answers to Questions Regarding the Lower Limb

Only two participants during the interviews stated the pain they felt in the lower limb whilst undertaking the trial was typical of marching either with or without a load. This was a skeletal pain in the heel that was also present whilst playing sports; the same participant also complained of mild hip pain that was typical of and only occurred during load carriage. The second was a skin discomfort at the hips caused by rubbing of the webbing. Two participants experienced pain that was not typical of marching with loads, these were mild foot arch and ankle joint pain. This may have been due to the forced-speed of the treadmill. Three participants mentioned they had knee pain when partaking in sports and one ankle pain. Marching and load carriage also induced these same feelings, but were not the causes of the injury.

Results from the questionnaire were very similar with fewer participants reporting discomfort in the lower limb compared to the upper limb, just 6 out of 10, with all these being mild discomforts. The most common site for reported discomfort was the foot with 4 complaints, then the leg with 3 and finally both the knee and ankle accounting for 1 case each. Although efforts were made to distinguish between blisters and actual foot pain (i.e. metatarsalgia or other musculoskeletal problems), one cannot guarantee that this foot discomfort was not just blistering. The cases of discomfort in the leg and foot were all stated as being typical of that whilst marching with loads. However, this was not the case with the knee and ankle as these weren't typical discomforts and may be due to walking at a fixed speed on a treadmill. Studies have shown differences in maximum ankle and knee angles in males with treadmill compared to over-ground walking[5], this may account for the discomfort felt here.

These findings support the notion that lower limb injury or discomfort does not represent a substantial short-term problem, especially within this sample group, after a 2 hour treadmill march with 20 kg. Any pain or discomfort was only mild and was not stated as restricting. This is supported by subjective data collected showing only one participant rating discomfort in the thigh (which was used as a control) as greater than 1. Lower limb injuries may represent a greater problem when looking towards the medium and long-term with tendonitis, joint degradation and particularly stress fractures of the tibia and metatarsals being major causes of injury. Increased vertical impact forces at heel strike during walking are a risk factor for the development of overuse injuries[6-8], the forces generated can be increased by a number of factors including load carriage[9-12]. Load carriage may also aggravate or cause the onset of previous injuries, especially in the knee or ankle.

Answers to Questions Regarding Blisters

Blisters were experienced by 5 out of 8 (63%) participants who took part in the interview study and 6 from10 (60%) with the questionnaire study. Although this may seem high other studies have found similar numbers affected, 69%[13] and 45%[14]. The most common site that blisters occurred during the questionnaire trial was the heel (8/13), then the balls of the feet (3/13) and finally the toes (2/13), figure 4. This again is similar to results from the interviews which found blisters were very typical whilst marching especially on the heels and balls of the feet.

Insert Figure 4 here

In an effort to establish the cause of blisters both studies questioned participants about their boots to ascertain if they considered their boots to be broken in. Four of the 5 interviewed participants who did get blisters considered their boots to be broken in and 5 from 6 in the questionnaire group, figure 5. This suggests that even if boots are broken in then blisters will occur and a combination of load, steps taken, stride length, speed or distance will determine blister rates. Infantrymen are at high risk for developing blisters due to the high external masses carried and prolonged periods of activity[15] (which increases both the number and ferocity of shear cycles and increases sweat production).

Insert Figure 5 here

According to participants from both trials blisters generally took between 1 and 3 days to disappear. The vast majority of participants who experienced blisters (8/11) termed them as self manageable, of the remaining 3 participants 2 would usually take no action and one would visit a clinic. Participants from both groups who did not experience blisters during the trial also mentioned they would rarely develop blisters at other times when marching either with or without a load.

During the interviews some participants raised the issue that blisters were typical whilst marching but only at the heels and balls of the feet. Two participants mentioned the formation of blisters on the toes, this was not typical of marching and was attributed to treadmill walking. Another 3 participants stated their blisters were more severe when walking on the treadmill compared to training in the field, this may be due to the increased heat produced by the treadmill. Blisters were so severe with two participants from the interview study they were forced to withdraw before the end of the trial.

Figure 6 shows the changes to foot discomfort over time for all participants who took part in the interview study. As can be seen there is a steady increase in pain mainly due to the development of blisters and hot spots. The graph suggests foot discomfort starts to materialise after about 30 – 45 minutes, as this is where the gradient starts to increase. The gradient of the line remains relatively constant until the end of the trial. Also represented on figure 6 is the discomfort data for those participants who completed the trial. The pattern of increases is almost identical, but foot pain does not materialise until 60 – 75 minutes of walking.

Insert Figure 6 here

The questionnaire then asked participants what they felt would most increase the discomfort caused by blisters or hot spots. There was a fairly even response with time and distance receiving 6 nominations each and load and speed 5. Foot blisters may represent a minor inconvenience to others but are a larger problem within the military. Knapik et al[14] state that 'Foot blisters can considerably reduce locomotion, impair concentration and affect the soldier's ability to respond to emergencies.' Also a broken blister can become infected due to limited sanitation in the field.

Conclusions

The upper limb is very susceptible to short-term injuries such as soft tissue damage and trapped nerves or blood supplies. The lower limb is not as affected by short-term discomfort but is at risk from overuse injuries. However, load carriage may aggravate or cause the onset of previous injuries, especially in the knee or ankle. The shoulders were rated as significantly more uncomfortable then any other region. Within the interview group 50% of participants rated shoulders as extremely uncomfortable and 2 were forced to withdraw. Blisters were experienced by around 60% of participants, and for the vast majority were typical of marching either with or without load. Shoulder discomfort commences almost as soon as load is added and increases steadily with time. However, foot discomfort seems to increase more rapidly once the discomfort first materialises. In conclusion, the early development of shoulder pain or blisters may be a risk factor for severe pain or non-completion of a period of prolonged load carriage.

Acknowledgments

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Table 1: Participant characteristics.

	n	Age (years)	Height (cm)	Weight (kg)
Interview	8	19.1 (± 14.1)	174.8 (± 14.0)	66.0 (± 18.2)
Questionnaire	10	21.2 (± 1.4)	178.3 (± 3.7)	73.7 (± 6.3)

Table 2: Scale used to rate comfort.

Comfort	Rating
Comfortable	1
Slightly Uncomfortable	2
Uncomfortable	3
Very Uncomfortable	4
Extremely Uncomfortable	5

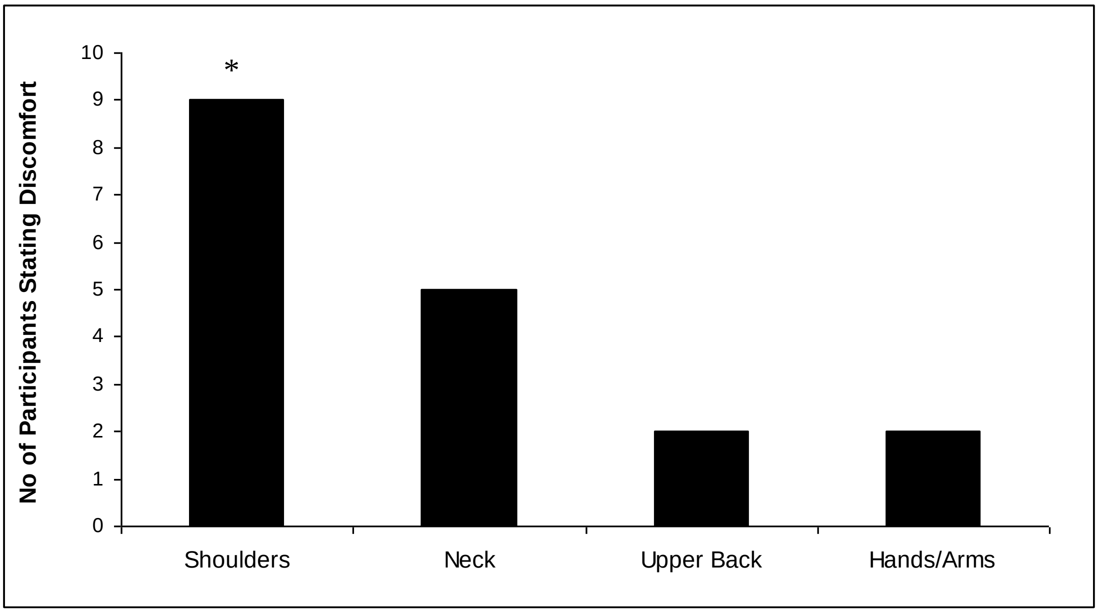

Figure 1: Most common sites for upper limb discomfort as stated by questionnaire group. * denotes significance of p<0.05.

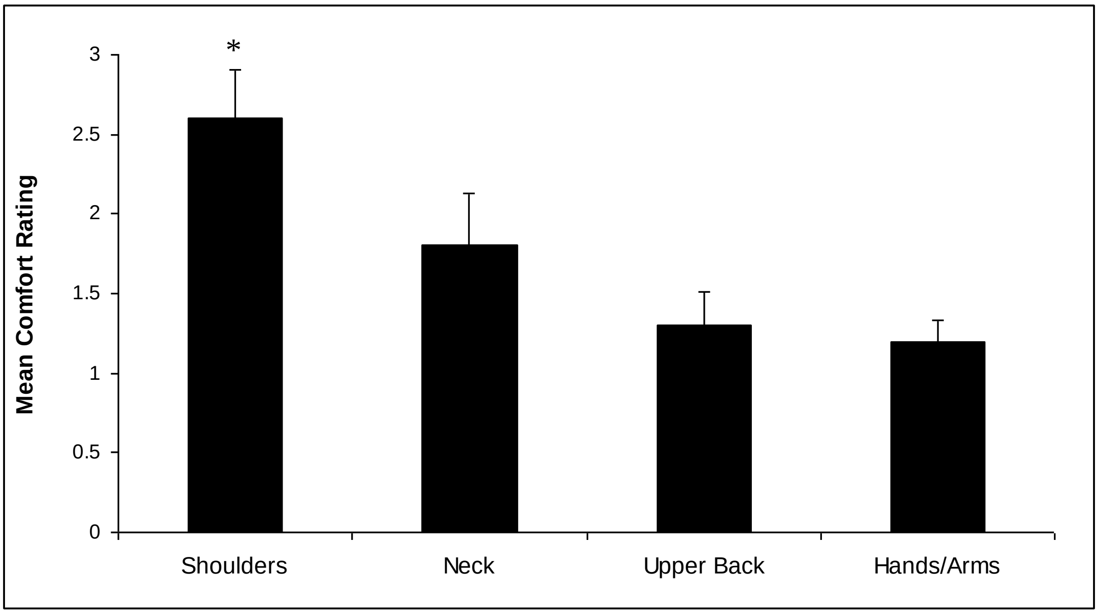

Figure 2: Mean comfort ratings for the upper limb as stated by the questionnaire group. * denotes significance of $p<0.05$.

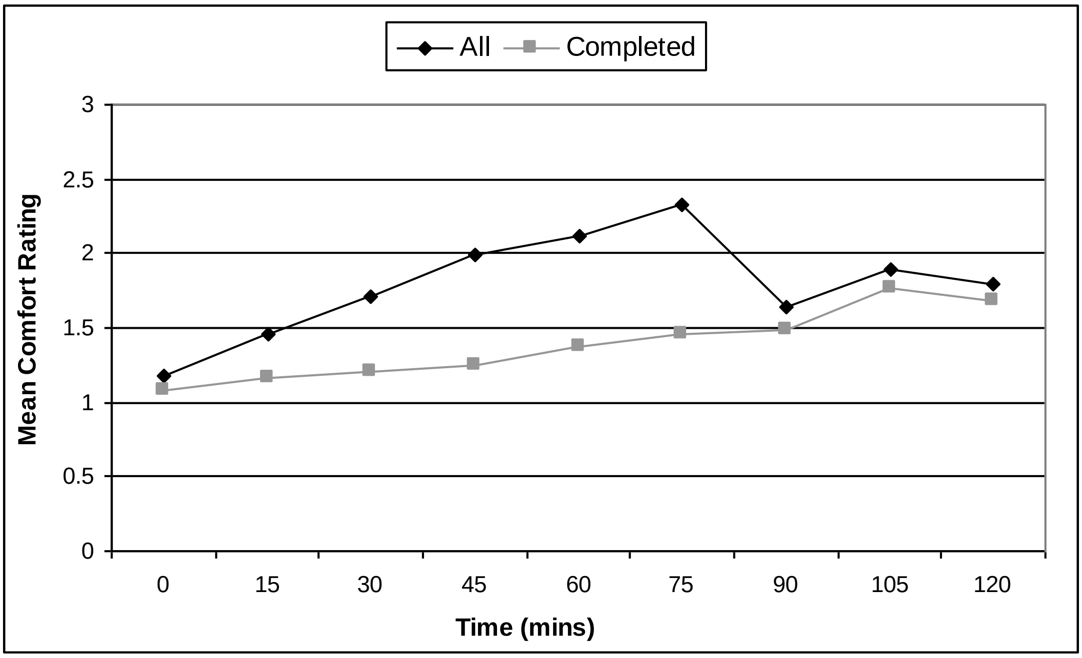

Figure 3: Change in shoulder discomfort over time for all participants and those who completed the trial from the interview group.

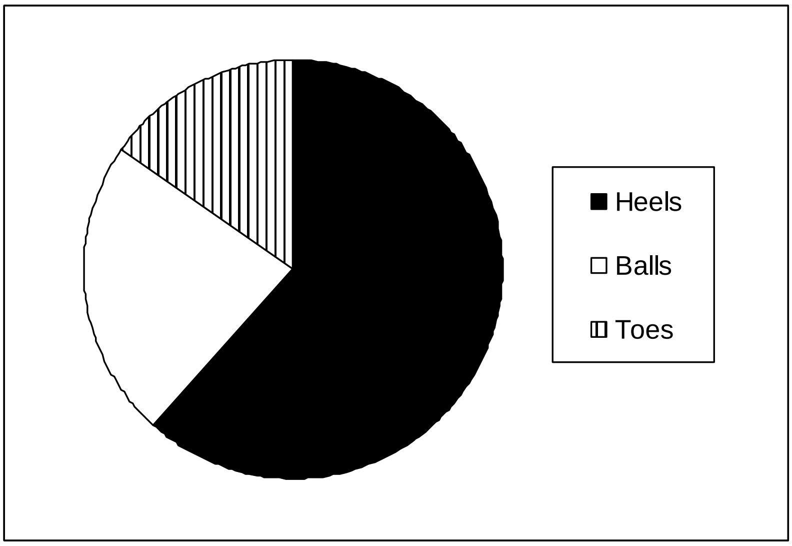

Figure 4: Most common sites for blister formation on the foot during the trial as given by the questionnaire group.

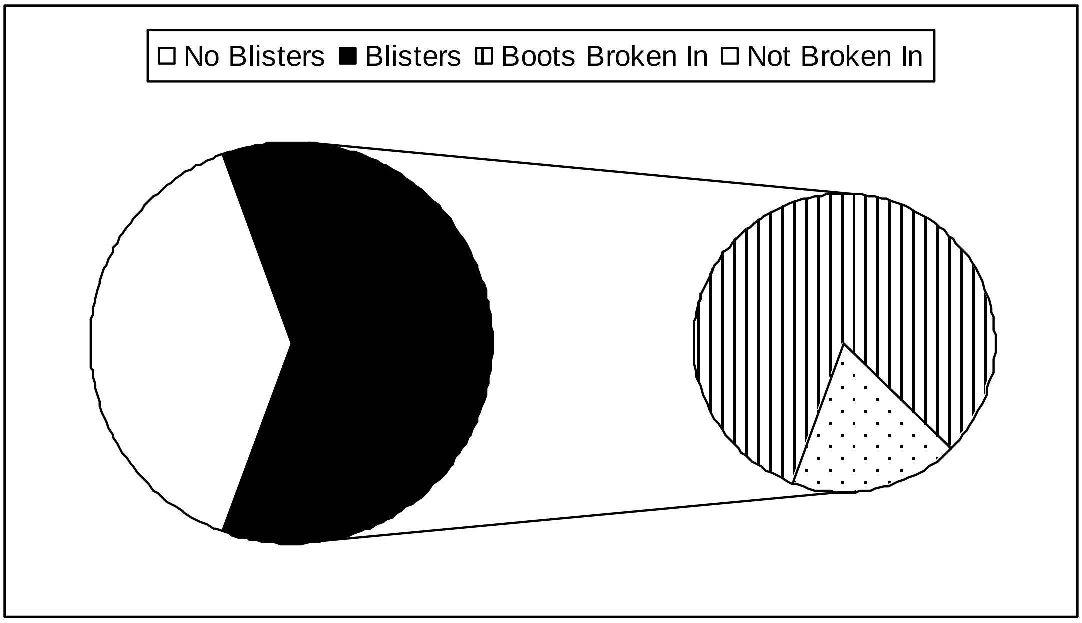

Figure 5: 1st Pie shows the proportion of participants (both studies combined) that experienced blisters (11/18), 2nd Pie illustrates the percentage of those that did have blisters who termed their boots to be broken in (9/11).

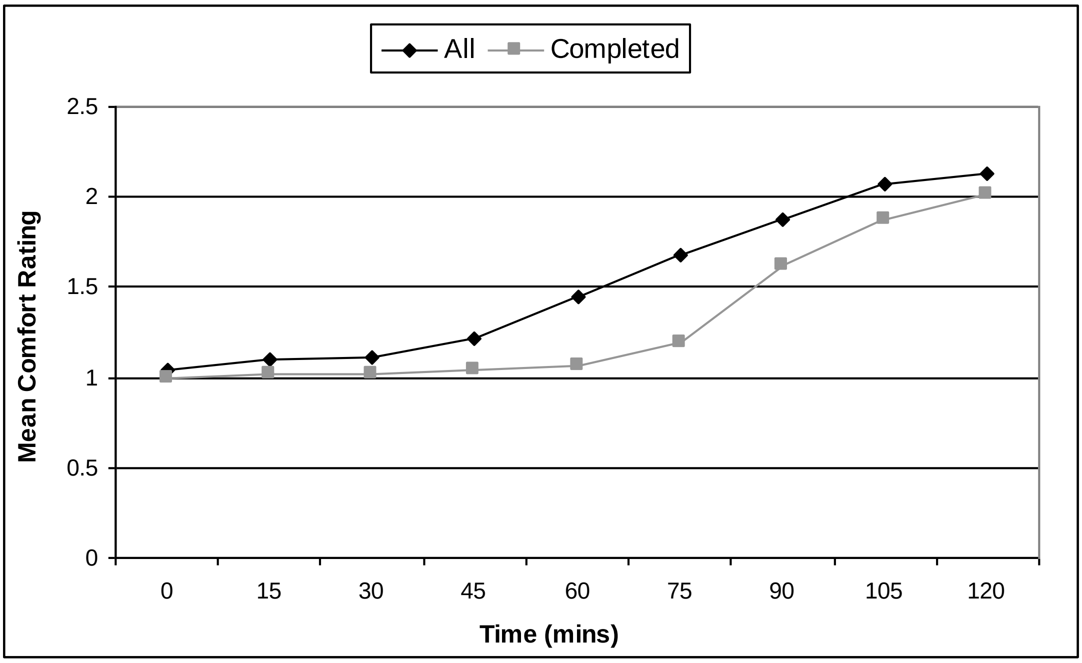

Figure 6: Change in foot discomfort over time for all participants who took part in the trial and for those that completed the trial.