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Breanne R. Carlson
*Northern Michigan Univeristy*, brcarlso@nmu.edu

Erich J Petushek
rajensen@nmu.edu

Marguerite Moore
mmoore@nmu.edu

Heather Dermyer



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# EFFECT OF SAUNA WARM-UP ON OVERHEAD SQUAT DEPTH IN ELITE WEIGHTLIFTERS

**Breanne R. Carlson[1], Erich J. Petushek[2], Marguerite Moore[1], and Heather Dermyer[3]**

**Department of Health and Human Performance, Northern Michigan University, Marquette, MI, USA[1]**
**School of Human and Health Sciences, University of Huddersfield, Huddersfield, UK[2]**
**School of Mind-Body Medicine, Saybrook University, USA[3]**

Ample total body flexibility or range of motion is important in Olympic style weightlifting. Although research has been conducted to study flexibility, little information exists regarding the use of saunas as an alternative modality for increasing flexibility. The objective of this study was to explore the effects of a fifteen-minute sauna session on overhead squat depth in 15 elite Olympic style weightlifters. Range of motion was assessed via video camera during a control and treatment session (3 trials at 4 time points). Overhead squat depth displayed excellent within- and between-session reliability. Repeated measures ANOVA revealed no significant changes in overhead squat depth following the sauna treatment ($p > 0.05$).

**KEYWORDS:** Flexibility, range-of-motion, Olympic weightlifting, snatch, heat, thermotherapy

**INTRODUCTION:** Excellent range-of-motion is imperative in Olympic style weightlifting (Fry *et al.,* 2006; Smalcerz, 1994). In order to catch the bar in the snatch or clean movement, one should have full shoulder, knee, hip, and ankle range-of-motion. This enables the athlete to catch the weight at the lowest possible point (Isaka *et al.* 1996) or maximize absorption distance (Chiu *et al.,* 2010) leading to a greater load lifted. Higher ranked weightlifters display greater snatch catch depth, compared to weight matched lower ranked weightlifters (Chiu *et al.,* 2010).

Rising tissue temperatures increase acute flexibility (Knight and Draper, 2008; Lehmann *et al.,* 1970), therefore sauna exposure may be a beneficial modality for increasing overhead squat depth. The sauna is a viable resource in the Olympic style weightlifting domain, as competitions and training centers must be equipped with a sauna to be in accordance with 3.3.1 of the International Weightlifting Federations Technical and Competition handbook. Currently there is no research on sauna as a modality to improve acute flexibility in weightlifters thereby improving squat depth, which may lead to improvements in performance. Although some research has been conducted to explore the efficacy of various thermotherapy modalities on range of motion, published information regarding the use of saunas as a means to increase flexibility was not found in the literature. Therefore the purpose of this study is to explore the effect of a fifteen-minute sauna session on overhead squat depth in elite weightlifters. The hypothesis is that the sauna treatment will have a significant increase on overhead squat depth flexibility in Olympic style weightlifters.

**METHODS:** To test the aforementioned hypothesis subjects overhead squat depth was assessed prior to and following sauna treatment. The treatment (sauna) and control conditions were randomized and counterbalanced over two testing sessions separated by one week. The independent variable was treatment condition. The dependent variable was the athlete's overhead squat depth. Reliability indices were also computed for the dependent variable.

**Subjects:** Eleven men and four women USOEC (United States Olympic Education Center) weightlifting athletes served as participants (national and international competition level). Participant specific characteristics are found in Table 1. The participants gave written informed consent prior to participation and this study was approved by the institutional review board.

**Experimental Procedures:** Subjects participated in two testing sessions: baseline (control) and sauna treatment. Subjects were tested on two consecutive Sundays as to accommodate their training regime. Session order was randomized. The baseline and sauna treatment sessions consisted of overhead squat depth assessment prior to and after fifteen minutes of rest and sauna exposure, respectively (with no dynamic warm-up). Fifteen minutes of sauna exposure was chosen based on previous recommendations for heat modalities to increase flexibility (Roberts and Wilson, 1999). Subjects wore a shirt and shorts that allowed for a full range-of-motion. The treatment took place in a sauna (K/FLC-120, Finlandia Sauna, Portland, OR, USA). The temperature was between 80°C and 90°C with a relative humidity of 40-50% (Shoenfeld *et al.,* 1976), this was verified using a Mannix digital thermo-hygrometer measured at face level (Model. *LAM 880D*, Cole-Parmer Instrument Co., Vernon Hills. IL, USA). In addition, a stopwatch was used for time keeping purposes. Subjects snatch grip width was measured from right to left index finger using a tape measure. Subjects' foot width was also measured from inside top right foot to inside top left foot. Overhead squat depth was assessed using a digital video camera (60 Hz, Exilim EX-F1, Casio Computer Co. LTD, Tokyo, Japan). A standard twenty kilogram barbell was used (111-0200, Eleiko Sport Inc, Chicago, IL, USA) with no load for all trials. An "X" was marked in the center of the barbell for digitizing purposes. Three overhead squats (Figure 1) were performed prior to and following a 15 minute control (sitting in 21°C room with same apparel) or sauna treatment condition on two separate days. Video was captured from a distance of three meters. Initial and final barbell position was determined using digitizing software (MaxTRAQ 2D, Innovision Systems Inc, Columbiaville, MI, USA). Specifically, overhead squat depth, in the vertical direction, was assessed using the following equation and reported as a percentage of initial overhead position (see Figure 1 also):

**Table 1**
**Subject characteristics (N=15).**

| Variable | Mean ± SD |
|---|---|
| Age (years) | 20.3 ± 1.9 |
| Height (m) | 1.7 ± 0.1 |
| Mass (kg) | 80.3 ± 16.9 |
| Best Snatch (kg) | 101.7 ± 28.6 |
| Best Clean & Jerk (kg) | 129.7 ± 30.8 |
| Practice (sessions/wk) | 6.3 ± 1.0 |

**Figure 1: (A) Initial and (B) final positions for overhead squat depth calculation.**

$$Overhead\ Squat\ Depth\ (\%) = 100 - \left(\left(\frac{Initial - Final}{Intial}\right) x100\right)$$

Lower percentages would indicate greater depth. All measurements were taken without any warm up or stretching. Water was available for subject ingestion ad libitum.

**Statistical Analyses:** A 3(trial) x 4(test session) repeated measures ANOVA was performed to determine any significant effects of sauna therapy on overhead squat depth. Reliability was assessed by repeated measures ANOVA, Intraclass correlation coefficient (ICC) and typical error or standard error of measurement (Batterham and George, 2003; Hopkins, 2012). Statistical Package for Social Sciences (Version 18.0, SPSS Inc., Chicago, ILL) was used for statistical analysis. Statistical significance was defined as $p \leq 0.05$.

**RESULTS:** Typical error throughout the sessions was around 1% equating to 1.8cm for the average initial height of the group. Specific reliability measures can be found in Table 2.

Overhead squat depth displayed excellent reliability during all sessions, according to the ICC classifications of Fleiss (Fleiss, 1986). Additionally, ANOVA results revealed no significant differences between trials during all sessions ($p$ = 0.051). There was no significant between session effects ($p$ = 0.275) or interaction between trials ($p$ = 0.623). The specific means and standard deviations prior to and following sauna treatment and control conditions are also located in Table 2.

**Table 2**
**Overhead squat depth values and reliability measures (N=15).**

| | Pre-Control | Post-Control | Pre-Sauna | Post-Sauna |
|---|---|---|---|---|
| Mean ± SD | 62.8 ± 2.4 | 61.9 ± 3.2 | 62.5 ± 3.3 | 62.4 ± 3.1 |
| Typical Error (CL) | 0.98(0.77-1.43) | 1.22(0.96-1.78) | 0.92(0.72-1.34) | 1.03(0.80-1.49) |
| ICC (CL) | 0.85(0.67-0.94) | 0.87(0.71-0.95) | 0.94(0.84-0.98) | 0.91(0.78-0.97) |

CL = 95% Confidence Limits; ICC = Intraclass Correlation Coefficient; Mean and Typical Error units are percentage of initial overhead squat position

**DISCUSSION:** Enhanced range-of-motion, during the snatch movement, is related to Olympic style weightlifting success (Chiu *et al.,* 2010; Fry *et al.,* 2006). Thus, effective and practical interventions to improve flexibility should lead to performance improvements. Contrary to the hypothesis, sauna treatment did not improve overhead squat depth. Although there is no specific previous research on sauna use and flexibility, our findings disagree with most research on heating modalities and their effect on flexibility. For example, exposure to pneumatherm, pulsed shortwave diathermy, static stretching, and active exercise all increased muscle flexibility (Cosgray *et al*., 2004; Draper *et al.,* 2004; Radford *et al*., 2006; Robertson *et al*., 2005). Conversely in other studies, no significant changes in muscle flexibility were found with moist heat packs or warm whirlpool (Cosgray *et al*., 2004; Robertson *et al*., 2005). However, there are other reasons for possibly not seeing a change in flexibility, as squat depth may be limited by soft tissue girth (i.e. calves). Also, Olympic weightlifters, among other athletes, have relatively high flexibility (Beedle *et al.,* 1991). Thus, they may have been "maxed" out (ceiling effect) on their flexibility potential in the overhead squat position. Thus, this study may be interesting to try on novice/beginner weightlifters or longitudinally, over more sessions. Future research needs to look into other methods to increase overhead squat depth or use more inflexible subjects, as they will have a larger window for opportunity to increase their flexibility. The influence/interaction of bar load (using loads similar to competition) may also contribute to flexibility characteristics. In addition, future investigations may consider the interaction with warm-up and cool down as interventions for improving flexibility.

**CONCLUSION:** Overall, a fifteen-minute sauna session did not have a significant acute effect on overhead squat depth in a sample of elite Olympic weightlifters. Thus, if a national level athlete is looking to increase their overhead squat depth, a fifteen-minute sauna session will not have the desired effect. The results from these athletes should be confirmed in other populations or over a longer intervention period (longitudinally).

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