ADDING SAUNA BATHING AFTER ENDURANCE TRAINING: A PRACTICAL INSIGHT FROM THE WORD'S TOP JUNIOR TENNIS PLAYER

Dario Novak, Petar Barbaros Tudor, Branka R. Matković

Faculty of Kinesiology, University of Zagreb, Croatia

Case report

Abstract

Sauna bathing is a form of heat exposure characterized by a short-term exposure to high air temperatures. There is very little evidence of the effects of sauna bathing on athletes. This case study involved the world's top junior female tennis player and 3 weeks of post-training sauna bathing was performed. Sauna bathing was performed immediately after endurance training sessions (12 bathing sessions spread over 3 weeks) by including the run to the sauna facility as a part of her training. Aerobic capacity, speed, agility, lower-body power and blood parameters were measured. All measurements were performed the day before the preparations training period and the day after completion of the preparation period. After the period of 3 weeks run time to exhaustion increased by 9.67% (15.5 vs. 17 min), maximal relative oxygen uptake by 8.58% (46.23 vs. 50.20 ml/kg/min) and anaerobic threshold by 16.66% (12 vs. 14). Plasma volume and red cell count increased by 7.47% (3.48 vs. 3.74 L) and 7.12% (3.93 vs. 4.21 10^12/L) respectively. Small progress occurred in motor abilities, agility and lower body power. We concluded that 3 weeks of post-exercise sauna resulted in no adverse effects on performance and the possible positive impact was present. More research is needed to confirm these findings in larger sample.

Key words*: sauna treatment, motor abilities, aerobic power, tennis*

Introduction

Sauna bathing is a form of heat exposure characterized by a short-term exposure to high environmental temperatures. The sauna is a log, or wood-paneled room, where the bathers relax on benches well above the floor level and the heat is produced through a mechanism involved in dry heat and rocks. The hot room air temperature falls within the range of 70 to 100°C, optimally between 80 and 90°C at the face level of the bathers (Kukkonen-Harjula & Kauppinen 2006). The air humidity, modified by bathers tossing water on the heated rocks, ranges from 15 to 30% relative humidity (Kukkonen-Harjula & Kauppinen 2006). This is considered a low humidity environment. There are many articles talking about risks and benefits of using sauna (Kaupinnen, 1989; Kukkonen-Harjula et al., 1989; Hannuksela & Ellahham, 2001; Kukkonen-Harjula & Kauppinen, 2006: Blum & Blum, 2007; Van der Wall, 2015) and especially about the benefits for the cardiovascular system (Prystupa et al., 2009; Laukkanen et al., 2015). Many of them indicates that the sauna bathing accelerates the heart rate up to twice the resting rate and even more (Kaupinnen, 1989, Kukkonen-Harjula et al., 1989; Kukkonen-Harjula & Kauppinen, 2006). The cardiac output is estimated to increase by about 70 % over the resting state, the total peripheral resistance of the vessels decreases by about 40 %, the stroke volume is unaffected, and the diastolic and mean arterial pressures decrease, with practically no change in the systolic pressure (Kaupinnen, 1989; Kukkonen-Harjula & Kauppinen, 2006). The overall work of the heart, as estimated from the heart rate and systolic blood pressure, indicating myocardial oxygen demand, does not increase greatly (Kukkonen-Harjula & Kauppinen, 2006). The skin temperature fluctuates from up to 40°C in the hot room, down to 33°C upon ice - water immersion (Kaupinnen, 1989; Kukkonen-Harjula & Kauppinen, 2006). The results of the research conducted so far show a beneficial effect of sauna bathing on the changes in blood biochemical parameters (Pilch et al., 2010). Editor-in-chief of JAMA Internal Medicine, Rita Redberg (2015) stated *"Although we do not know why the men who took saunas more frequently had greater longevity—whether it is the time spent in the hot room, the relaxation time, the leisure of a life that allows for more relaxation time or the camaraderie of the sauna—clearly time spent in the sauna is time well spent."*

There is very little evidence of the effects of sauna bathing on athletes but some investigation showed that sauna bathing immediately after an exercise provides an additional training stimulus especially in endurance performance (Ridge & Pyke, 1986; Scoon et al., 2007), while there were no effects on anaerobic exercise performance (Cheuvront et al., 2006.). There is also some evidence of positive

effects in thermoregulation (Tyka et al., 2008) and sauna is widely accepted in the process of weight reduction in combat sports particularly (Franchini et al., 2012).

In the present study we therefore investigated endurance performance and some for tennis play interesting motor abilities of top junior tennis player following a period of adaptation to sauna bathing undertaken immediately after training sessions. We included measurement of plasma volume and red cell count to see their possible contribution to any enhancement of performance.

Methods

The subject in this study was an elite junior female player who was number one junior in the world while this study was conducted (International Tennis Federation Ranking list, July, 2014). She was at the age of 17; ranking on the ITF world junior list, No 1.

Her parents gave written consent in accordance with the requirements of the Declaration of Helsinki and The Committee for Scientific Research and Ethics approved the investigation.

Her body height was 174.0 cm, body mass 66.1 kg and body mass index 21.83 at the beginning of the study. The performance test was a run to exhaustion. Speed, agility, and lower-body power and blood parameters were measured.

The study was performed during her summer off-season (July 14 – Aug 3 2014). Blood parameters were measured and all motor and endurance measurement were performed the day before the preparations period started and the day after completion of the preparation period. Sauna bathing was performed immediately after endurance training sessions (12 bathing sessions spread over 3 weeks) by including the run to the sauna facility as part of her training. She was expected to stay in the sauna for 20 min, which produced tolerable discomfort in preliminary trials. She sat in an upright position in the sauna. Fluid intake was ad libitum. Heart rate was recorded before entering, and every 5 min while in the sauna, using a Polar RS 800 heart rate monitor (Polar Electro, Kemplele, Finland). Blood pressure was also recorded before entering and every 5min while in the sauna, using a mercury sphygmomanometer and stethoscope. Sauna temperature was recorded every 5 min with a mercury thermometer fixed ~1.8m from the floor. Nude body mass accurate to 0.01 kg was measured immediately before and after each session (Wedderburn Scales, Teraoka Seiko, Tokyo, Japan). Subject was instructed to drink fluid equivalent to any difference in pre- and post-sauna mass within 2 h of leaving the sauna (Scoon et al., 2007). The performance test was a run to exhaustion performed at constant speed and 1% slope on a Run Race moving treadmill (Technogym, Italy, length 190 cm, width 60 cm), with the possibility for fine-tuning speed from 1-25 km/h, with a shift of 0.1 km/h; *Quark* b^2 (Cosmed, Italy) portable automated, computerized system that allows for continuous ('breath by breath') gathering, graphic display, printing, storage, and analysis of the measured ventilation, metabolic and ergometric parameters. The measuring system consists of a respiratory mask for the nose and mouth (Hans Rudolph, USA), which is connected to the bi-directional turbine with Optoelectric airflow reader. Air sample (1 ml/s) is drained via Permapure Nafion capillary tube (removes moisture without changing the concentration of the gases) to the fast analyzers which measure the concentration of gases (O_2 and CO_2), with an accuracy of ±0.03%; and Polar Vantage NV (Polar ElectroOi, Finland) telemetry system for monitoring the heart rate rhythm. The system consists of the receiver and two electrodes with a transmitter (1m range, fastened around the chest by elastic straps). All of the above mentioned devices are connected (via the interface and peripheral inputs) and controlled by a personal computer and appropriate software. Blood volumes were measured using a dye dilution method (El-Sayed et al., 1995). Furthermore, speed (5m, 10m, 10m flying and 20m sprints), agility (T-movement, side steps and backward running), lower-body power (squat jump (SJ), countermovement-jump (CMJ), countermovement-jump with arm swing and 7 repeated jumps) were measured before and after the 3-week preparation period. Table 1 shows a summary of the 3-week preparation period. Training types are divided into three basic groups which were present during the preparation period (technical and tactical training; neuromuscular training; and endurance training). Technical and tactical training was focused on raising the level of particular kinds of knowledge, whereas neuromuscular training included training of strong characteristics in the gym and in the field, as well as speed training, agility training, and power training. The endurance training included specific intervals of aerobic and anaerobic session, which were conducted in accordance with the individual characteristics of the tennis player. It is worth pointing out that the contents of this prevention training (flexibility, proprioception, and global mobility and stability) were conducted within the bounds of the neuromuscular training (Table 1).

Table 1. The 3-weeks preparation period summary

	Week 1	Week 2	Week 3
Technical and tactical training	0 min 0	500 min 6 sessions	450 min 5 sessions
Neuromuscular training	525 min 5 sessions	600 min 6 sessions	180 min 2 sessions
Endurance training	315 min 4 sessions	210 min 4 sessions	180 4 sessions
Number of trainings	9	14	12
Number of matches	0	2	4

Results and discussion

It is sometimes believed that children and adolescents should not take sauna baths because of its dangers (Markkola et al., 1989). Yet, most children in many Scandanavian countries are introduced to the sauna at the mean age of five months, and many of them continue to take a sauna bath at least once a week throughout their life (Markkola et al., 1989; Kukkonen-Harjula & Kauppinen, 2006). Based on the present scientific knowledge, sauna bathing poses minimal risks to healthy people from childhood to old age.

Table 2. Blood parameters and body mass before and following sauna treatments for the elite junior tennis player

	Pre-testing	Post-testing
Plasma volume (L)	3.48	3.74
Lymphocytes (%)	15.7	32.5
Erythrocytes (10^12/L)	3.93	4.21
Hemoglobin concentration (gL^{-1})	122	128
Hematocrit (fraction)	0.39	0.36
Body mass (kg)	66.1	66.6

Tables 2 to 4 show the values before (pre-testing) and after (post-testing) the 3-weeks training period of elite junior female player. It is obvious that the values of blood parameters at the end of the training cycle were significantly different from those at the beginning of the cycle. Increases in plasma volume and erythrocyte number was clear (3.48 vs. 3.74 and 3.93 vs. 4.21) (Table 2). This was expected, considering the fact that the training was conducted following sauna bathing procedures. The heat stress of a single session of sauna bathing produces an increase in plasma volume (Hannuksela & Ellahham, 2001). A reduction in renal blood flow during sauna bathing as well as the plasma volume expansion could provide the stimulus to produce more erythrocytes due to more intensive release of erythropoietin (Pagel et al., 1988). The increase in total blood volume and more erythrocytes could enhance high-intensity endurance performance by delivering more oxygen to muscles (Luetkemeier & Thomas, 1994). This type of improvement could be very beneficial for tennis athletes for their performance as well as for their faster and better recovery. It is, however, also worth pointing out that sample size in this case study is too small to produce a clear outcome and it is difficult to understand if the improvements are due to the sauna or just the regular training, but it is worthy to say that sauna was the only new thing in the training schedule. Despite the increase in erythrocyte number hematocrit showed a bit lower values after the observed period pointing out that haemodilution is more pronounced than red cells number augmentation.

It is common knowledge that acute exercise produces different changes in immune cell distribution and even in their function (Gjevestad, et al., 2016; Gleeson, 2007). Regular training, and especially increase in training load, is usually linked with the decrease in lymphocyte number (Gleeson, 2007). Improvement in lymphocyte percent in our subject could be connected with some recent studies that showed that hypoxic training produced favorable outcomes for immune system (Wang et al., 2011.).

Table 3. Endurance performance parameters before and following sauna treatments for the elite junior tennis player

	Pre-testing	Post-testing
Run time to exhaustion (min)	15.5	17
Relative maximal oxygen uptake ($mlO_2/kg/min$)	46.23	50.20
Maximal heart rate (bpm)	194	192
Anaerobic threshold (km/h)	12	14
Heart rate at anaerobic threshold (bpm)	180	173

The run to exhaustion produces a small error of measurement (Scoon et al., 2007). Table 3 shows that the greatest progress is seen precisely in the parameters describing the endurance performance. Run to exhaustion and relative maximal oxygen uptake has been increased by 9.67% (15.5 to 17 km/h) and 8.58% (46.23 to 50.20 $mlO_2/kg/min$), respectively. Relative maximal oxygen uptake at anaerobic threshold has also been increased from 12 to 14 km/h (16.66%), which allows the player to deal with greater strains introduced by more intense points without entering the anaerobic zone.

The changes in blood parameters and changes in performance are likely the reason for the performance enhancement, given that plasma volume expansion alone can improve endurance performance (Leutkemeier & Thomas, 1994; Scoon et al., 2007). The insufficient amount of time, that

is, the brief period of development, is probably the reason for the small progress achieved in motor abilities, but still there are improvements in agility and lower body power (Table 4). Nevertheless, the effects of sauna bathing need to be substantiated with a larger sample size.

Table 4. Motor performance parameters before and following sauna treatments for the elite junior tennis player

	Pre-testing	Post-testing
5m sprint (s)	1.09	1.09
10m sprint (s)	1.9	1.9
10m flying start (s)	1.4	1.4
20m sprint (s)	3.3	3.3
Agility T-movement (s)	11.52	11.29
Side steps (s)	6.51	6.4
Backward 10m sprint (s)	2.83	2.75
SJ (cm)	25.5	28.2
CMJ (cm)	28.15	29.15
CMJ arm swing (cm)	34.2	35.5
7 repeated jumps (cm)	25.1	26.8

SJ – squat jump, CMJ – counter movement jump

Tennis today requires the tennis player to have a very high level of readiness. However, the periodization in tennis is extremely demanding. One of the reasons for this is a large number of important tournaments which are being held continually during the calendar year. Tournaments are held on different surfaces, in different continents, and in different weather and climate conditions, which makes it even harder to approach planning and programming of training cycles. Tennis players are expected to be in optimal condition on a large number of tournaments during the year, and there is no time for the "long" preparation period. That is why all the training stimuli which provides a quick performance enhancement are very beneficial. The data obtained in this case study provides some initial support for the use of sauna treatments during the recovery period during a training period for elite level tennis athletes. Sauna bathing for 20 minutes immediately after a training may provide an additional training stimulus and motor and endurance performance could be enhanced.

Practical implications

- Sauna bathing for 20 minutes immediately after a training session may provide an additional training stimulus.
- After 12 bathing sessions spread over 3 weeks, motor and endurance performance of elite junior tennis player is enhanced.
- Elite junior tennis players may experience gains from sauna bathing.

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BORAVAK U SAUNI KAO DODATAK TRENINGU IZDRŽLJIVOSTI: PRIMJER VRHUNSKE MLADE TENISAČICE

Croatian abstract

Boravak u sauni je oblik toplinske izloženosti karakteriziran kratkotrajnom izloženošću visokim temperaturama zraka. Vrlo je malo znanstvenih dokaza o učincima boravka u saunama na sportaše. Ova studija slučaja opisuje učinak saune na vrhunsku svjetsku tenisačicu juniorskog uzrasta. Tenisačica je tijekom 3 tjedna, u 12 zasebnih prilika, boravila po 20 minuta u sauni na temperaturi 90 ± 2.0 ◦C neposredno nakon treninga izdržljivosti u koji je bilo uključeno i trčanje do saune. Tijekom boravka u sauni praćena je frekvencija srca. Od motoričkih sposobnosti mjerene su izdržljivost, brzina, agilnost i snaga donjih ekstremiteta te je učinjena kompletna krvna slika. Sva mjerenja provedena su dan prije početka pripremnog perioda i dan nakon završetka razdoblja priprema. Po završetku pripremnog perioda zabilježen je porast vremena potrebnog za postizanje iscrpljenosti za 9.67% (15.5 vs. 17 min), maksimalni relativni primitak kisika povećao se za 8.58% (46.23 prema 50.20 ml/kg/min) i anaerobni prag za 16.66% (12 vs 14). Volumen plazme i broj eritrocita povećan je za 7.47% (3.48 u odnosu na 3.74 L) i 7.12% (3.93 prema 4.21 10^12/L). Mali napredak zabilježen je u motoričkim sposobnostima, agilnosti i snazi donjih ekstremiteta. Zaključujemo da boravak u sauni nije imao štetnih učinaka na motoričke sposobnosti tenisačice, dapače da je moguć i pozitivni učinak. Potrebno je naravno više istraživanja za potvrđivanje ovih nalaza, a posebno je potrebno primijeniti veći uzorak što će omogućiti donošenje kvalitetnijih zaključaka.

Ključne riječi: *sauna, tenis, motoričke sposobnosti, aerobni kapacitet*

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Corresponding information:
Received: 23 January 2018
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Correspondence to: Prof.dr.sc. Branka Matković
University: University of Zagreb
Faculty: Faculty of Kinesiology
Phone: 00385-98-729847
E-mail: bmatkovic@kif.hr