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Athlete and practitioner prevalence, practices, and perceptions of passive heating in sport

Original article

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Abstract:

Recent research into passive heating has shown that it can enhance performance when used as; a stimulus for heat acclimation, part of regular training, or during a warm-up. However, this research is contradictory to established practices such as ice baths in the case of recovery. The current usage and understanding of passive heating within sport is unknown. This study aimed to establish the current prevalence, practices and perceptions of passive heating from athletes and sport science practitioners within sport using an online survey. Of the 343 respondents, 62% of athletes and 69% of practitioners reported using passive heating within their sport, with a greater prevalence amongst combat sport athletes or athletes competing at a higher standard ($p < 0.05$). The most commonly reported purpose of engaging in passive heating for athletes was recovery (66%), and for practitioners was heat acclimation (64%). Most athletes previously engaging in passive heating perceived it to be beneficial for its intended purpose (86%), providing anecdotal evidence to support its use where there currently is no scientific evidence. Moreover, transient negative consequences, such as dizziness or fatigue, were experienced by 55% of athletes highlighting the potential detrimental effects passive heating could have on training or performance that should be considered by athletes and practitioners. Therefore, this survey establishes key differences between scientific understanding and sporting practices whilst identifying areas of future development for the use of passive heating within sport.

Keywords: Heat, Hot water immersion, Sauna, Recovery, Acclimation, Survey

Introduction:

Passive heating involves the application of heat to the body at rest through means such as hot-water~~hot water~~ immersion, sauna-bathing or heated-clothing and can induce some similar physiological responses to exercise, including acute increases in core and muscle temperature, heart rate and blood flow [1–6]. Accordingly, passive heating has recently received interest from the scientific community in the context of sport due to suggested beneficial effects on heat acclimation [7], exercise recovery [8], injury rehabilitation [9], physiological adaptation [10], and warm ups [11]. However, the emerging nature of this research means the extent to which these suggested applications of passive heating are being implemented by athletes and practitioners is currently unknown.

The potential benefits of passive heating are context and protocol specific and, therefore, its applicability is dependent on the demands and objectives of any given sport or training session. Whole-body heating modalities including sauna-bathing or hot-water immersion may be the most effective method of increasing core temperatures due to the incompensable heat stress, whilst greater muscle temperature can be achieved without increasing core temperature to the same extent by using hotter local heating methods, such as heated-clothing or shortwave diathermy. Indeed, 2 h~~ours~~ of hot water perfused around only the arms increases intramuscular temperature of the triceps brachii by ~5 ˚C without altering core temperature [12], whilst the same duration in waist-deep 42 ˚C water increases vastus lateralis temperature by ~4 ˚C in addition to increasing core temperature by ~1.5 ˚C [4]. Moreover, the duration and temperature of the passive heating exposure also influence these physiological responses with longer and hotter exposures resulting in greater increases in temperature [7]. Accordingly, passive heating protocols may vary greatly between sports dependent on the desired outcome. For example, in combat sports, such as judo or boxing, that are divided into weight classifications, prolonged passive heating may be used to induce high sweat rates resulting in short term weight loss ahead

of weigh in [13–15]. However, in other sports, such as sprint cycling or swimming, application of heated-clothing for ~30 min as part of the warm-up may be a more appropriate use of passive heating due to the acute maintenance/elevation of muscle temperature resulting in greater muscular power production [16] and improved performance [11, 17]. In addition to these transient benefits, repeated passive heating exposures can elicit chronic adaptations such as reduced resting core temperature [18], increased capillary density [19], mitochondrial biogenesis [20], red blood cell volume [21], vascular function [22], and muscle volume [23], which are of differing levels of importance in different sports. Therefore, the purpose and timing of passive heating usage may differ between sport types dependent on the desired outcome.

The broad scope of the term passive heating means that while some passive heating protocols offer potential benefits in specific contexts, many others may offer no benefit or even be detrimental for athletes. For example, whole-body passive heating may impair muscle glycogen resynthesis [24], whilst localised heating can accelerate muscle glycogen recovery [12, 25]. Indeed, the effects of passive heating on recovery appear to be mixed with studies showing beneficial [26–28], detrimental [29, 30], or no effect [31, 32], re-emphasising the context specific nature of passive heating. Moreover, passive heating has been reported to induce negative consequences, such as dizziness or headaches [33], which are likely a manifestation of heat illness [7] or orthostatic intolerance [34, 35]. In extreme cases, passive heating may even lead to hospitalisation or death [33, 36]. However, the prevalence of these consequences is influenced by many factors, such as acclimation status, age and fitness level [37–39]. Therefore, knowledge of the appropriate frequency, type, temperature, and duration of passive heating for safe and effective use is essential for athletes and sport science practitioners.

The use of strategies that can compliment training and optimise performance are common practise within sport. For example, cold water immersion is often used to accelarate perceptions of recovery [40], whilst British endurance runners consider hypoxic/altitude training to be important in increasing their physiological improvements [41]. Despite emerging scientific evidence of the utility passive heating could have within sport, it is unknown whether this knowledge is being implemented by athletes and sport science practitioners. Similarly, where current practise is believed to be beneficial but does not align to the current scientific literature, this anecdotal evidence can assist in the formulation of research questions to either support or oppose current practise. Therefore, this study aimed to investigate the sport specific prevalence, practices and perceptions of passive heating by athletes and sport science practitioners.

Methods

Ethics - Following ethical approval from Coventry University Ethics committee (P119742), participants were recruited between March and September 2021 via a web link to the survey circulated by social media (e.g. Twitter, Facebook groups) and email. Inclusion criteria were stated as athletes of any level in any sport between 18 and 40 years of age OR sport science practitioners within high-level sport. Passive heating was defined to participants as the application of heat to the body at rest (e.g. hot tubs, saunas, heated clothing) and was presented along with the survey aims and requirements prior to participants giving consent, which was required to subsequently view the questions.

Survey design - The survey aimed to capture the prevalence, practices and beliefs of passive heating within sport from athletes and sport science practitioners (practitioners) across a range of sports. The survey was designed and distributed using Jisc (https://www.onlinesurveys.ac.uk) and had two distinct pathways to separate questions relating to athletes and practitioners. Questions and multiple-choice responses were based on previous

research and postulated effects/benefits of passive heating in a sporting context. A full copy of the survey can be found in the Supplementary material, however, briefly, the survey questions covered the following areas:

- Demographic information - age, sex, nationality, sport, and competition standard. (Survey pages: 4—5 practitioners; 6—7 athletes).
- Passive heating usage - typical modality, duration, purpose, and timing of passive heating exposures, and any associated negative symptoms. (Survey pages: 9—10 practitioners; 16—20 athletes).
- Perceptions of the benefits of passive heating—athletes responded to the statement "In my sport, I believe passive heating could be useful to…" on a four-point scale of strongly agree to strongly disagree on the potential uses of passive heating (weight loss, injury rehabilitation, recovery, etc.). (Survey pages: 14—15 practitioners; 12—13 athletes).
- Barriers to passive heating. (Survey pages: 10—11 practitioners; 20—21 athletes).

Data analysis - Data were analysed in RStudio and are reported as frequency counts and percentages. To generate themes, athlete responses were grouped based on sport type into four categories: Team sports (e.g. football, rugby, hockey), Endurance sports (e.g. endurance events within athletics, road cycling, rowing), Combat sports (e.g. judo, boxing, taekwondo), and Other (e.g. gymnastics, field events within athletics, weightlifting). The same categories were used to group practitioner responses except for Endurance sports, which was replaced by Linear sports (e.g. athletics, cycling, swimming) to reflect that a single practitioner may have jurisdiction over a large spectrum of events with differing physiological demands (e.g. sprints and endurance). For statistical comparisons, the chi-square test of independence was used to determine differences between variables, unless the minimum expected frequency was ≤ 5 where the Fisher's exact test was used instead. Where significant at a group level, pairwise

155 comparisons with Bonferroni corrections were performed on sub-groups. Significance was
156 determined by $p \leq 0.05$.

157 **Results**

158 *Demographic information* - A total of 295 athletes and 48 practitioners completed the survey.
159 Athletes were all aged 18–40 (median 24), with 60% of the sample being male, and the most
160 common competition standard being club (39%). The majority of the sample was from or
161 working in the United Kingdom (87% athletes; 69% practitioners). Practitioner job roles were
162 primarily physiologists, performance scientists, strength and conditioning coaches, or sport
163 scientists. Athlete demographic characteristics differed regarding competition standard by
164 sport type. For example, combat sports athletes made up 61% of the international sample whilst
165 only 11% of at club level. Summary characteristics for the whole sample and a breakdown by
166 sport type are displayed in Table 1, with the full frequencies of respondents by sport available
167 in the Supplementary material.

168 *Passive heating usage* - There was a similar prevalence of athletes and practitioners who have
169 previously used passive heating (62 % vs. 69 %, $p = 0.34$). Amongst athletes, the prevalence
170 of passive heating users differed by sport type ($p = 0.0004$) and competition standard ($p =$
171 0.0004), with a greater prevalence amongst combat sport athletes than all other sport types (Fig.
172 1A), and a greater prevalence in athletes of higher competition standards (Fig. 1B). No
173 statistical difference was found for prevalence of passive heating users amongst practitioners
174 for either sport type ($p = 0.06$) or years' experience ($p = 0.26$) (Fig. 1). However, 100% of
175 practitioners with 15+ years' experience and those from combat sports reporting previously
176 using passive heating. Of the 33 practitioners who reported previously implementing passive
177 heating, 70% reported currently using passive heating with their athletes.

Of the 182 athletes reporting to have previously used passive heating, the majority reported utilising a principle modality of either hot-water immersion (57%) or saunas (28%), with heated clothing (9%) and heat chambers (2%) less frequently used. Across all usage, the most frequent modality reported by practitioners was also hot-water immersion (76%) followed by heat chambers (48%), saunas (42%), and heated clothing (33%). Examples of "Other" passive heating modalities included heat packs, heated towels, hot-waterhot water bottles and heat lamps. The durations of exposure most frequently reported by athletes were 5–15 minutes (38%) and 15–30 minutes (38%). Longer durations of 30–45 minutes and 45+ minutes had a smaller prevalence of 11% and 10%, respectively, with very few athletes reporting a duration of 0–5 minutes (2%). In the absence of temperature data to characterise the heating stimulus, perceptual responses from a typical heating exposure showed that the most reported thermal sensation to be Hot (54%), compared to Warm (17%) or Very Hot (29%), with thermal comfort being more frequently Comfortable (64%) than Uncomfortable (36%).

Fewer than half (45%) of athletes that were passive heating users reported never experiencing any negative symptoms/side effects, with the majority reporting experiencing 1–3 different symptoms (53%). The most commonly reported symptoms were dizziness (32%), fatigue (23%), drowsiness (18%), headaches (14%), or nausea (6%), with more severe consequences such as fainting (2%) or vomiting (1%) being less prevalent. There was no difference in the prevalence of these symptoms between sport types (Combat 66%, Endurance 51%, Team 50%, Other 51%, $p = 0.31$). However, typical perceptual responses were related to the incidence of these negative consequences with a main effect of both thermal comfort ($p = 0.031$), and thermal sensation ($p = 0.0012$), with pairwise differences between every level of thermal sensation (Fig. 2 A). There was no effect of reported heating modality ($p = 0.26$) or duration ($p = 0.19$) and the prevalence of negative symptoms (Fig. 2).

Recovery from training was reported as the most common purpose of passive heating amongst athlete responses (66%). In contrast, heat acclimation (44%) was the most prevalent purpose reported by practitioners. A breakdown of the purpose and timings athletes and practitioners engaged in passive heating is shown in Fig. 3. Between different sport types, the athlete prevalence of each purpose of passive heating was similar with the exception of weight loss which was more prevalent in combat sport athletes than the other sport types ($p < 0.001$). Similarly, combat sport practitioners reported a higher prevalence for short term weight loss than the other sport types ($p < 0.001$), whilst team sport practitioners reported a higher prevalence for recovery than linear sport practitioners ($p = 0.007$). Examples of "Other" purposes of passive heating included relaxation, enjoyment and cultural norm. There was a greater prevalence in the lead up to competition for combat sport athletes than the other sport types ($p < 0.001$) and a greater prevalence during preseason training for team sport athletes than endurance athletes ($p = 0.001$).

Perceptions of the benefits of passive heating - Of the total 343 responses, a similar proportion of athletes and practitioners (76 % vs. 83%, $p = 0.35$) believed passive heating could be useful in their sport, with only 4% of athletes believing passive heating offered no benefit. The breakdown by sport type of perceived usefulness passive heating could have for each given purpose is shown in Fig. 4. Of athletes who reported previous engagements in passive heating, 86% reported it to be of perceived benefit for the intended purpose, with 2% perceiving no benefit and the remaining 12% being unsure.

Barriers to passive heating - Most athletes reported at least one barrier to engaging in passive heating (92%). Of these, the most commonly reported barrier was a lack of facilities (74%) or a lack of time (36%), with use of alternate strategies (14%), lack of perceived benefit (7%) and experiencing negative symptoms (5%) less prevalent. Of the 16 practitioners having never previously used passive heating, none expressed no desire to implement passive heating in the

future. Barriers reported by practitioners included lack of facilities (29%), with use of alternate strategies (15%) and lack of perceived benefit (13%) less prevalent. Barriers listed in "Other" include a lack of awareness/understanding, lack of current need for heat acclimation, and logistical issues surrounding team sport engagement. Lack of current need (50%) and lack of facilities (40%) accounted for 90% of practitioners who previously implemented passive heating but are not currently using it with their athletes (n = 10).

Discussion

This study aimed to investigate the sport specific prevalence, practices and perceptions of passive heating by athletes and practitioners. The findings showed that 62% of athletes and 69% of practitioners have previously used passive heating, with a higher proportion (76% and 83%, respectively) believing that passive heating can be useful in their sport. Some differences between sport types were observed for the purpose of engaging in passive heating highlighting the context specific nature of the potential benefits. Athlete practices were often not aligned to scientific evidence supporting their usage, however, large belief from athletes in the beneficial effects of passive heating provide anecdotal evidence that warrant further investigation. Additionally, this survey found mild transient negative consequences, such as dizziness or fatigue, being a relatively common occurrence (55% of athletes) following passive heating meaning athletes and practitioners should be aware of the potential negative effects passive heating could have on training or performance. Accordingly, these results highlight areas for future development of passive heating both within the scientific understanding and applied practice.

The prevalence of passive heating users was highest amongst combat sport athletes (85%). This is consistent with saunas and hot-water~~hot water~~ immersion being widely used to induce rapid weight-loss prior to competition in these sports [13–15], with protocols of 40~~–~~–60 min~~utes~~ of

intermittent heating in either 70 °C sauna or 39 °C water have been shown to induce ~2% decrease in body mass [42, 43]. However, there are reports of far more extreme protocols being used with fatal consequences [36, 44]. Despite emerging literature supporting the efficacy of passive heating in a number of contexts, such as heat acclimation [18, 45] and competition warm-up [11, 17], the prevalence amongst athletes engaging in passive heating for these purposes was relatively low across all sport types. This could be partially explained by a lack of awareness of passive heating, which was expressed as a reason for not engaging in passive heating by 15% of athletes. Indeed, as access to better informed coaches/practitioners may be a reason why passive heating usage was higher amongst higher level athletes, although 16% of practitioners were unsure if passive heating could be beneficial within their sport and athletes of a lower level may be faced with a multitude of other barriers including reduced access to facilities or a lack of time. However, these observations highlight the potential to increase knowledge amongst athletes and practitioners of the possible benefits of passive heating.

Across all sport types, the most commonly reported purpose for engaging in passive heating by athletes was recovery (66%). Similarly, recovery was the second most prevalent purpose for engaging in passive heating amongst practitioners, with a higher prevalence amongst practitioners from team sports compared to linear sports. This observation is consistent with previous research showing sauna-bathing is considered an important method of recovery in a variety of populations by both athletes and practitioners [46, 47]. However, this demonstrates that practise is not always research led as studies have found conflicting outcomes when using passive heating as a recovery modality, with increased stress and impaired next day performance [29, 30], and mixed outcomes for glycogen resynthesis [12, 24, 25, 31] and the reduction of muscle soreness [27, 48]. It is unclear from this study whether the current usage and belief in passive heating as a recovery modality comes from scientific research. However, 85% of athletes in the present study, engaging in passive heating for the purpose of recovery

perceived it to have been beneficial, which is similar to the 78% previously shown to perceive cold water immersion to be beneficial [40]. This belief in passive heating could itself have a positive effect on recovery as cold water immersion research has shown a large psychological or perceptual component to recovery, with an athlete's belief of recovery or the placebo effect relating to beneficial outcomes [49, 50]. Accordingly, more research is required to investigate the psychological or physiological responses to specific passive heating protocols in order to elucidate specific mechanisms that may impact exercise recovery.

Amongst the many modalities of passive heating, hot baths or hot tubs were reported as the most common by athletes (57%) and practitioners (76%) in the present study. As the most commonly reported barrier to passive heating was a lack of facilities (74%), this supports previous suggestions that of hot-waterhot water immersion offers a simple, accessible and cheap method of heating and is, therefore, more practical than saunas or environmental heat chambers [7, 18]. Similarly, athletes most frequently reported a heating duration of 5—15 (38%) or 15—30 minutes (38%). The modality, duration and temperature of a protocol is likely to influence the effect passive heating has on the desired outcomes. A survey of sauna users reported the median duration of sauna sessions to be 16 minutes with relaxation being the primary motivation for sauna-bathing [33]. However, in sport similar recovery outcomes to no heating have been found after 14 minutes of hot-waterhot water immersion following both muscle damaging exercise and high-intensityhigh intensity exercise [27, 32], with beneficial effects of passive heating typically observed following a longer heating duration. For example, a duration of 20—40 minutes elicits improved sprint performance following a warm-up [11], promotes heat acclimation [18, 45], and increases haematological, vascular, and muscular adaptation [19–23].Therefore, whilst these longer durations may be required for physiological effects, either acutely or when repeated to elicit chronic adaptation, passive heating of a shorter

5–15 minutes duration may be sufficient to elicit short term psychological benefits such as a relaxation or a placebo effect that may subsequently lead to positive outcomes.

Belief in the utility of passive heating was high amongst both athletes and practitioners with 76% of athletes believing passive heating could be useful in their sport and of passive heating users 86% perceived it to be beneficial for its intended purpose. Indeed, lack of a perceived benefit was not stated as a reason for any practitioners no longer implementing passive heating that had done so previously. Instead, a lack of facilities or a lack of current need were the main reasons for not currently engaging in passive heating. Lack of current need (e.g. "not currently preparing for a competition in a hot climate") highlights the nature in which passive heating usage may differ based on competition or ambient conditions that alter across a calendar year. Indeed, the present data does not capture this information and only gives a retrospective analysis of whether athletes have previously used passive heating at least once. Furthermore, data regarding the frequency in which athletes engage in passive heating for a given purpose was not obtained in the present study which limits knowledge of how athletes use passive heating to modality, duration, purpose and timing. Given this information is likely context specific, future research should aim to investigate the frequency of passive heating usage within particular sports focusing on a given purpose.

Despite many positive reported effects of passive heating, over half of the athletes (55%) also reported previously experiencing negative consequences following a bout of passive heating. The most frequent symptoms were dizziness (32%), fatigue, and headaches (14%), however, the presence of negative symptoms was not a barrier to engaging in passive heating for most respondents in the present study (95%) suggesting they are considered an acceptable occurrence by end-users. The incidence of these negative symptoms following specific passive heating protocols are rarely reported within the scientific literature, but are likely a manifestation of heat illness [7] or orthostatic intolerance [34, 35]. Individual factors, such as

acclimation status, influence the incidence of these negative consequences potentially explaining the lack of effect of duration or heating modality observed in the present study [38]. However, the effect demonstrated between thermal perception and the incidence of negative consequences warrants further investigation. Accordingly, athletes and practitioners should be aware of the risks involved when engaging in passive heating and decide what negative consequences are acceptable (e.g. mild dizziness); while researchers should better characterise and understand the potential negative side effects of passive heating and investigate the impact on training and competition (e.g. Skorski et al. [29]).

Despite some promising findings about the usage and perceptions of passive heating by athletes and practitioners, some of these findings should be interpreted with caution. For example, the sub-group analyses in the present study were of limited sample size and, therefore, could not detect significant effects of certain interactions (e.g. Practitioner sport type and prevalence, the interaction between sport type and competition standard on prevalence). Combat sport athletes make up 59% of the total athletes of an international competition standard but only 9% of athletes at club level, meaning it is possible that the interaction between sport type and competition level in these athletes confound the significant findings of sport type and competition standard in this study. However, the increased prevalence with higher competition standards appears to be present across all sport types and between sport types at each competition level (Supplementary material). Moreover, the reported prevalence of passive heating in the present study may be an overestimate of passive heating usage within sport due to selection bias with athletes currently engaging passive heating potentially more likely to respond to the survey as advertised on social media. Finally, the findings from the primarily British sample in the present study should not be generalised globally due to differing natural exposure to hot environments and/or differing cultural norms around the world, such as sauna-bathing in Scandinavia or hot baths Japan

where passive heating is commonly used, which may alter the prevalence and purposes of engaging in passive heating.

Conclusion:

In summary, this survey shows that passive heating is used for a range of purposes across different sport types. Whilst highly prevalent in combat sports for inducing rapid weight loss, passive heating is less well established amongst other sports, but currently appears most frequently used for recovery. This is perhaps surprising due to the lack of conclusive research on the effects of passive heating on recovery, but given 85% of athletes in the present study reported perceived beneficial effects, researchers may need to investigate this more robustly. Athletes of a higher competition standard are more likely to have previously engaged in passive heating, perhaps reflective of fewer barriers such as facilities or time constraints in elite populations. Indeed, hot baths were the most frequently used modality of passive heating, supporting the notion that they are a practical and accessible modality that can be used effectively in the real world. However, the current practises of athletes do not always align to the research showing benefits of passive heating. This highlights the potential for athlete and practitioner education on the positive and negative effects of specific passive heating protocols, as well as revealing areas that warrant further investigation by researchers due to perceived benefits from current users.

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Informed consent: A total of 343 participants provided informed consent via the online survey which included both consent to participate and consent that the data could be used for publication.

Data availability: Data can be found in the supplementary material.

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Fig 1 Prevalence of passive heating usage amongst athletes (light grey) and practitioners (dark grey) by A - Sport Type (Athletes), B – Competition Standard (Athletes), C – Sport Type (Practitioners), and D – Experience (Practitioners). Numbers above each bar show number of passive heating users/total responses in that sport type. Significant difference from Combat, International and National is denoted by *, #, and †, respectively

Fig. 2 Incidences of athletes reporting at least one negative symptom following a typical passive heating exposure by A – perception of thermal sensation, B - perception of thermal comfort, C – modality, and D – duration. Numbers show number of athletes experiencing symptoms/total number of athletes in each category. Significant difference from Uncomfortable, Very hot and Hot is denoted by *, #, and †, respectively

Fig. 3 Differences between sport types for A – athlete purposes, B – athlete timings, and C – practitioner purposes. Significant difference from Combat and Team is denoted by *, and #, respectively.

Fig. 4 Breakdown of responses (A – Athletes and B – Practitioners) by sport type for the agreement in the potential benefit of passive heating for each listed purpose

Table 1. Demographic characteristics for athletes and practitioners

Athlete characteristics	Overall	Combat	Endurance	Team	Other
Responses	295	60	138	65	32
Passive heating users	182	51	74	37	20
Age: Median (LQ, UQ)	24 (21, 29)	23 (21, 27)	23 (21, 29)	27 (22, 31)	22 (20, 26)
Sex: Males / females	177 / 118	34 / 26	88 / 50	40 / 25	15 / 17
Nationality: UK / other	258 / 37	46 / 14	122 / 16	60 / 5	30 / 2
Competition standard:					
Non-competitive	44	5	28	2	9
Club	116	11	55	45	5
Regional	47	7	26	8	6
National	56	18	22	7	9
International	32	19	7	3	3
Practitioner characteristics	**Overall**	**Combat**	**Linear**	**Team**	
Responses	48	6	21	21	
Passive heating users	33	6	16	11	
Nationality: UK / Other	33 / 15	5 / 1	11 / 10	17 / 4	
Experience:					
0—2 years	6	0	2	4	
2—5 years	10	2	5	3	
5—10 years	9	1	6	2	
10—15 years	16	3	4	9	
15+ years	7	0	4	3	

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