The Competition-Day Preparation Strategies of Strongman Athletes

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Abstract

Winwood, PW, Pritchard, HJ, Wilson, D, Dudson, M, and Keogh, JWL. The competition-day preparation strategies of strongman athletes. *J Strength Cond Res* 33(9): 2308–2320, 2019—This study provides the first empirical evidence of the competition-day preparation strategies used by strongman athletes. Strongman athletes ($n = 132$) (mean ± *SD*: 33.7 ± 8.1 years, 178.2 ± 11.1 cm, 107.0 ± 28.6 kg, 12.8 ± 8.0 years general resistance training, 5.9 ± 4.8 years strongman implement training) completed a self-reported 4-page internet survey on their usual competition-day preparation strategies. Analysis of the overall group and by sex, age, body mass, and competitive standard was conducted. Ninety-four percent of strongman athletes used warm-ups in competition, which were generally self-directed. The typical warm-up length was 16.0 ± 8.9 minutes, and 8.5 ± 4.3 minutes was the perceived optimal rest time before the start of an event. The main reasons for warming up were injury prevention, to increase activation, and increase blood flow/circulation, temperature, and heart rate. Athletes generally stated that competition warm-ups were practiced in training. Dynamic stretching, foam rolling, and myofascial release work were performed during warm-ups. Warm-up intensity was monitored using the rate of perceived exertion, perceived speed of movement, and training load (as a percentage of 1 repetition maximum). Cognitive strategies were used to improve competition performance, and psychological arousal levels needed to increase or be maintained in competition. Electrolyte drinks, caffeine, and preworkout supplements were the commonly used supplements. These data will provide strongman athletes and coaches some insight into common competition-day preparation strategies, which may enhance competition performances. Future research could compare different competition-day preparation strategies in an attempt to further improve strongman competition performance and injury prevention.

Key Words: warm-up, injury prevention, cognitive, nutrition, hydration, caffeine, performance

Introduction

In recent years, the sport of strongman has surged in popularity both as a spectator sport and in the active number of competitors, catering for women, lightweight, and Masters competitors. The inclusion of strongman implements and associated strongman training exercises has also become an area of emphasis in the training programs of athletes (52,59). Common strongman exercises use equipment such as loaded frames, stones for lifts and carrying, loaded sleds, and vehicles for pulling, and logs, tires, and oversized dumbbells for lifting (55). Strongman is a sport that is similar to the sports of weightlifting, powerlifting, and Highland Games, where training is primarily focused on the improvement of maximal strength and power to improve competition performance (43,44,55). However, unlike the other weightlifting sports, which have their standard required lifts to be performed in every competition, strongman competitions are unique in which events can be ever changing and are designed to challenge the athlete's functional strength, endurance, power, and cardiovascular ability. Such differences in the physiological demands of strongman compared with the other weightlifting sports suggest that strongman athletes may use unique competition-day preparation strategies (i.e., specific warm-up, cognitive, and nutrition strategies, etc.) to help improve competition performance. Currently, a paucity of information exists on the competition-day preparation strategies the strength athletes use.

In today's modern sporting environment, warming up before competition is widely accepted as a good practice, with athletes and coaches alike believing that warming up is essential for reducing the risk of injury (6,57) and attaining optimal performance (14,34). Over the past decade, extensive research has been conducted to better understand the physiological and neural mechanisms associated with the warm-up and the subsequent performance changes after different types of warm-ups (4,5,14,34). The main outcomes associated with warming up are an increase in muscle temperature (39), muscle metabolism (19), muscle fiber conduction velocity (37), $\dot{V}O_2$ kinetics (38), and increases in muscle contractile performance (40). For detail on the physiological mechanisms and effects of warming up on performance, readers are referred to the review articles by McGowan et al. (34) and Fradkin et al. (14), respectively.

Two major categories of warm-up have been identified in the literature, which include passive warm-up and active warm-up.

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Passive warm-ups involve raising muscle or core temperature by some external means such as hot showers or baths, saunas, and heating pads without depleting energy substrates (5). Active warm-up involves exercise and is likely to induce greater metabolic and cardiovascular changes than passive warm-up (4). The structure, intensity, duration, recovery duration, and specificity of the active warm-up will depend on many factors, including the task to be undertaken, the physical capabilities of the athlete, the environmental conditions, and also the constraints imposed by the organization of the event (4).

The warm-up period is also an opportunity for athletes to mentally prepare ("psych-up") for upcoming events and concentrate on the task/s ahead. A number of cognitive strategies typically used by athletes are preparatory arousal, imagery, goal setting, attentional focus, and positive self-talk (45,48). Researchers have found that "psyching up" may increase muscular endurance (20,30), muscular strength (50,51), power (18,21), and athletes' task execution (22,25). However, the effects of psyching up on task execution may be determined by the specific demands of the task (7). Brody et al. (7) found no significant differences in isometric elbow flexion force among 15 strength-trained men when subjected to 3 preparatory conditions (psyching, reading aloud, and mental arithmetic). Given the technical and tactical complexity of the sport of strongman, it is quite likely that strongman athletes would use a number of cognitive strategies to improve competition performances.

Technological advances over the past decade have facilitated the emergence of new types of warm-up strategies. Kilduff et al. (28) suggested that strategies such as an appropriately designed warm-up, passive heat maintenance, remote ischemic preconditioning, morning exercise, hormonal priming, and post-activation potentiation (PAP) could optimize performance of short-duration high-intensity sports on the competition day. Kilduff et al. (28) suggested that there is an additional window on the day of competition where performance can be acutely enhanced and proposed a theoretical timeline outlining how each aforementioned conditioning strategies could be incorporated into the athlete's precompetition routine to enhance performance. Given that strongman athletes may have to compete over several hours or days it would be of great interest to determine what competition preparation strategies strongman athletes use during this time period.

Researchers have investigated the training (55) and tapering practices (53) of strongman athletes. Although these studies provide insight into how strongman athletes train and periodize their training to prepare themselves for the physiological stresses of competition, no data exist in the scientific literature on the competition-day preparation strategies these athletes use. Because strongman athletes may be at a greater risk of injury during competition than training (54), it is important to determine what preparation strategies are used to minimize injury and optimize strongman competition performance. The purpose of this study was to determine (a) what competition-day strategies strongman athletes use and how they are implemented on the basis of the athletes sex, age, body mass, and competitive standard and (b) to determine whether competition strategies differ between common strongman events (i.e., farmers' walk, log lift/press, and stone lifts/work). It was hypothesized that strongman athletes would perform specific warm-ups before strongman events and use cognitive and nutritional strategies to improve competition performance, with only relatively minor differences between athletes of different sex, age, body mass, and competitive standards.

Methods

Experimental Approach to the Problem

A comprehensive strongman competition-day preparation survey (strongman survey) was administered online and aimed at identifying the competition-day strategies used by strongman athletes. The research hypothesis was that most strongman athletes responding to the online survey would perform warm-ups before strongman events and use cognitive and nutritional strategies to improve competition performance. The strongman survey created for this study was adapted from questions previously used with strongman athletes' tapering practices (53), competition-day preparation strategies of swimmers (33), and the performance strategies of US Olympians (45). A test-retest reliability study performed with 64 strongman athletes demonstrated that online surveys can provide stable and reliable answers for most questions (56).

Subjects

Two hundred and fifty-four subjects accessed the online survey, which included those who observed the survey, partially completed the survey, and the 132 (52%) who completed the survey. Subject inclusion criteria were male and female strongman athletes who were between 18 and 60 years old and had competed in at least 1 strongman competition. The criterion for a completed survey was that the subjects completed the first 2 sections of the questionnaire on demographics/background information and warm-up strategies. The methods and procedures used in this study were approved by the Institutional Review Board Committee at ToiOhomai Institute of Technology (TRC 2017.056).

Procedures

Subject Recruitment. Strongmen athletes were recruited through professional networks and multimedia methods similar to previously described procedures (53–55). Strongman athletes were sent a letter through Facebook Messenger, which contained an invitation to participate in the research and the link to the online survey. Presidents of the World Strongman Federation and Strongman Corporation emailed the survey link to their club members. Strongman clubs in New Zealand, Australia, Europe, the United States, and the United Kingdom were also contacted and asked to distribute the survey link to their club members. An information sheet outlining the objectives and purpose of the study was situated on the first page of the online survey. Subjects indicated their consent by filling in the survey. The software used allowed subjects to exit the survey at any time and complete at a later date, allowing subjects to provide their data at the time most suitable to them. Surveygizmo.com was used to launch the electronic survey on the internet.

Research Instrument. Strongman athletes completed a self-reported 4-page, 32-item, retrospective strongman survey (Supplemental Digital Content 1 (see http://links.lww.com/JSCR/A148) created for this study based on questions previously used with strongman athletes (53), swimmers (33), and the US Olympians (45).

The strongman survey consisted of 4 main areas of inquiry: (a) demographics and background information; (b) warm-up strategies; (c) cognitive strategies; and (d) other competition strategies. Background information included questions on age, sex, height,

body mass, resistance training experience, strongman training experience, and competitive levels. The warm-up strategy section included questions pertaining to purposes of the warm-up, warm-up length, training intensity, and rest periods between sets and whether the warm-up was self-directed or coach-led. Warm-up strategies were defined as "the physical preparation performed before the start of a strongman event/competition." Subjects were asked to detail their common/typical values for each question. The cognitive strategies section included questions on psych arousal and the use of previously defined cognitive strategies (e.g., positive self-talk, emotional control, automaticity, and goal setting) used in research (45,48). Cognitive strategies were defined as "self-directed mental interventions used before or during the execution of a strongman event to enhance strongman competition performance" (49). The other competition strategies section included questions on other types of strategies performed (e.g., sports massage, stretching, etc.), supplements and substances used, and nutritional strategies incorporated on the competition day. Closed questions were used for Sections 1 and 3, with open and closed questions used for Sections 2 and 4. For Sections 2, 3, and 4, additional comments could be made by athletes for most questions.

Statistical Analyses

Mean and *SD*s were calculated for demographics, training, and warm-up characteristics. Frequencies of responses were collated for questions related to warm-up practices, cognitive and nutrition strategies, and supplement/substance use of strongman athletes. Categorical and ordinal data were reported as both absolute numbers and percentage of responses.

Answers to open-ended questions and comments associated with closed questions were content analyzed by investigators who were experienced with qualitative methods of sports science research and content analysis (53). During data analysis, investigators generated raw data and higher-order themes through independent, inductive content analysis and compared independently generated themes until consensus was reached at each level of analysis. At the point of development of higher-order themes, deductive analysis was used to confirm that all raw data themes were represented. In some cases, the subjects provided greater depth of information that represented more than 1 concept and hence responses contributed to more than 1 higher-order theme.

Demographics and training experience were calculated for all subjects. The subgroups of sex, age (≤30 and >30 years), male body mass (lightweight <105 kg and heavyweight ≥105 kg), and competitive standard (local/regional amateur, high level amateur, and international level) were calculated based on those previously reported in strongman research for male athletes (54). The body mass classes of female subjects (light to middle weight <80 kg and middle to heavyweight ≥80 kg) were chosen post hoc to allow for a similar sample size for group comparisons and reflect the approximate female body mass class divisions typically seen in strongman. A 2-tailed unequal variance *t*-test was used to determine whether any statistical differences ($p \leq 0.01$) existed in the demographics and training experience of the strongman athletes as a function of sex, age, and body mass. A 1-way analysis of variance (ANOVA) with Games Howell post hoc tests was used to determine whether statistical differences existed among competitive standards. For data that did not follow normal distribution, the Mann-Whitney and Kruskal Wallis (with Bonferroni post hoc pairwise comparisons) nonparametric tests were used (respectively).

Differences among the subgroups regarding the use of passive warm-ups, PAP, practising competition warm-ups in training, and whether the athletes warmed up for every event were analyzed with a chi-square test. Repeated-measures ANOVA with Bonferroni pairwise comparisons were used to determine whether any statistical differences existed among strongman events (farmers' walk, log lift/press, and stone lifts/work) in regard to the number of warm-up sets, distance/repetitions performed, loads used (as a percentage of 1 repetition maximum [%1RM]), and rest periods used between sets. Significance was accepted at the $p \leq 0.01$ level. All statistical analyses were performed using SPSS 22.0 for Windows (SPSS, Inc., Chicago, IL, USA), and higher-order themes were generated using Microsoft Excel (version 9.0; Microsoft, Seattle, WA, USA).

Results

Demographics, Training Characteristics, and Warm-up Length

One hundred and thirty-two strongman athletes from 18 countries completed the strongman survey. The majority of athletes were from the United States (61%), Australia (12%), and Canada (9%). Demographics and training experience of the subjects (n = 132) are presented in Table 1. The strongman athletes were (mean ± *SD*) 33.7 ± 8.1 years, 178.2 ± 11.1 cm, 107.0 ± 28.6 kg, and had 12.8 ± 8.0 years general resistance training experience. The average strongman implement training experience and years competing in strongman among all lifters was 5.9 ± 4.8 years and 5.4 ± 4.7 years, respectively. Strongman athletes indicated their typical warm-up length was 16 ± 8.9 minutes, and 8.5 ± 4.3 minutes was the mean time between the end of competition warm-up and subsequent strongman event.

Subgroup analyses revealed that males had significantly greater resistance training experience (years) (14.6 ± 7.5 vs. 7.0 ± 4.9), strongman training experience (years) (6.4 ± 4.7 vs. 3.4 ± 2.0), and years competing in the sport of strongman (5.9 ± 4.5 vs. 3.3 ± 1.9), than women. Differences were also observed among local/regional athletes who had significantly less ($p \leq 0.01$) strongman training experience (3.6 ± 2.4 years vs. 7.2 ± 5.4 years) and years competing in the sport of strongman (3.1 ± 4.4 kg vs. 7.2 ± 5.3 kg) than international-level athletes. Male and female athletes in the heavier body mass classes were significantly heavier than their lighter counterparts, and heavier male athletes were significantly taller (186.5 ± 8.4 vs. 176.8 ± 6.0) than lighter male athletes.

Warm-up Characteristics

Ninety-four percent of strongman athletes indicated that they used a warm-up in strongman competitions with 6% (n = 8) of athletes indicating that they only sometimes warm up. Of the 132 strongman athletes in this study, 90% (n = 119) indicated that their warm-ups were self-directed, whereas 8% (n = 10) indicated their warm-ups were coach-led. The main reasons and purposes reported by strongman athletes for warming up are presented in Table 2. The 3 main themes emerging from the data were injury prevention, increase activation, and increase blood flow/circulation, temperature, and heart rate.

The competition warm-up characteristics of strongman athletes are reported in Table 3. Eighty-one percent of athletes indicated that they warmed up or sometimes warmed up for every strongman event during a single competition. The most common reason stated for warming up for every event were as follows: the

Table 1

Demographics, training experience, and warm-up length (mean ± *SD*) for strongman athletes (*n* = 132).

		Sex		Body mass				Age		Competitive standard		
				Male (*n* = 98)		Female (*n* = 34)						
	All strongman athletes (*n* = 132)	Male (*n* = 98)	Female (*n* = 34)	≤105 kg (*n* = 43)	>105 kg (*n* = 55)	<80 kg (*n* = 17)	≥80 kg (*n* = 17)	≤30 y (*n* = 51)	>30 y (*n* = 81)	Local/regional amateur (*n* = 34)	High-level amateur (*n* = 61)	International level (*n* = 37)
Demographics												
Age (yrs)	33.7 ± 8.1	33.2 ± 7.8	34.0 ± 7.1	31.8 ± 6.2	34.7 ± 9.7	35.1 ± 7.5	33.9 ± 7.0	26.2 ± 3.0	37.8 ± 6.0*	31.3 ± 5.5	33.9 ± 8.3	34.8 ± 7.9
Height (cm)	178.2 ± 11.1	182.4 ± 8.8	166.4 ± 8.6*	176.8 ± 6.0	186.5 ± 8.4*	163.4 ± 6.5	168.2 ± 6.2	178.0 ± 11.2	178.4 ± 11.3	180.2 ± 10.1	176.5 ± 11.3	179.3 ± 12.1
Body mass (kg)	107.0 ± 28.6	115.6 ± 25.3	82.1 ± 16.0*	92.5 ± 8.3	132.0 ± 19.8*	70.5 ± 5.8	94.2 ± 13.7*	106.8 ± 29.3	107.1 ± 26.5	107.5 ± 24.3	103.0 ± 26.8	113.5 ± 31.0
Training experience												
Resistance training experience (yrs)	13.0 ± 8.0	14.6 ± 7.5	7.0 ± 4.9*	13.6 ± 5.8	15.8 ± 9.2	7.3 ± 4.5	6.6 ± 4.9	8.4 ± 4.4	15.3 ± 8.0*	12.6 ± 5.8	12.5 ± 7.7	13.0 ± 9.3
Strongman experience (yrs)	5.9 ± 4.8	6.4 ± 4.7	3.4 ± 2.0*	5.8 ± 3.6	7.3 ± 6.0	4.1 ± 2.5	2.9 ± 1.4	3.6 ± 2.0	6.9 ± 4.9*	3.6 ± 2.4†.004	5.9 ± 4.1	7.2 ± 5.4
Years competing (yrs)	5.4 ± 4.7	5.9 ± 4.5	3.3 ± 1.9*.002	5.3 ± 3.4	7.1 ± 6.4	3.8 ± 2.2	2.8 ± 1.5	3.3 ± 2.0	6.4 ± 4.7*	3.1 ± 4.4†	5.4 ± 3.7	7.2 ± 5.3
Warm-up												
Warm-up length (min)	16.9 ± 8.9	17.1 ± 8.9	16.3 ± 9.2	15.3 ± 8.7	18.4 ± 8.8	15.6 ± 9.3	17.1 ± 9.2	16.9 ± 9.4	16.9 ± 8.7	13.7 ± 6.4	17.8 ± 9.1	18.4 ± 10.1
Optimal time between warm-up and event (min)	8.5 ± 4.3	8.7 ± 4.5	7.7 ± 3.7	9.0 ± 5.5	10.0 ± 5.9	8.4 ± 3.8	7.8 ± 3.2	8.1 ± 4.3	8.7 ± 4.4	7.6 ± 3.9	8.2 ± 4.6	9.7 ± 4.2

*Significantly different to another level of variable $p = \leq 0.001$ unless specified.

†Local/regional amateur significantly different ($p = \leq 0.001$; unless specified) to the international level.

Table 2

Main reasons and purposes of the warm-up reported by strongman athletes (n = 132).*

Higher-order themes	Responses	Selected raw data representing responses to this question
Injury prevention	57	"To prevent injury, and a good warm-up helps me actually lift more."
		"I feel less likely to injure myself on deadlift and overhead events if I "grease the groove" a bit."
		"Warm up muscles and get blood flow to prevent injury."
Increase activation†	51	"Getting the body ready to move and the nervous system primed to perform."
		"Fire up the muscles used for the lift and to get a feel for the weight/implement."
		"Main focus is to activate muscles and get blood flow."
Increase blood flow/circulation, temperature‡ and heart rate	50	"Mainly, I perform warm-ups to get my blood flowing, joints and muscles warm, and to feel the weight of the implement."
		"Increase blood flow and lubrication to the muscles and joints, to prepare them for the work ahead."
		"Warm up muscles, joints, tendons, etc. and elevate heart rate."
Increase mobility/flexibility	46	"Mobility/flexibility to keep everything ready to perform."
		"Loosening of muscles and increased ROM of joints."
		"Flexibility/stretching and working through tough range of motions."
§Movement familiarization	40	"Loosen up, get a feel for the weight, practice the general movements."
		"Warm up the muscles, work up to the weight of the event, and get use to the piece of equipment."
		"Get a feel for specific implement I'll be using."
		"All equipment is different and has a different feel to it."
Psychological factors	21	"Gain confidence with the feel of the implements and blood flow."
		"To prepare internal environment, behavior, and decision-making strategies related to event."
		"...Reduce competition stress and mentally prepare for the lifts to come"
		"Loosen up and get mentally in the zone."
Improve performance	14	"Better performance in event competition."
		"To successfully set myself up to perform at my very best while reducing the risk of injury."
Miscellaneous	5	"Routine helps me ground myself in unknown situations."
		"To determine if I have anything going on in the body which seems abnormal and may need additional time/work."
		"Depends on events, weather."

*N.B. In some cases, the subject provided information that represented more than 1 concept and their response contributed to more than 1 higher-order theme.
†Includes CNS and muscle activation.
‡Includes muscle and body temperature.
§Includes strongman implement familiarization and load familiarization.
ROM = range of motion.

long rest times between events (athletes had to get warm again), injury prevention, and the technical aspect and loads associated with the events require practicing the specific movement patterns. Significant differences were observed between female body mass classes (χ^2 = 9.47, degrees of freedom = 2, $p < 0.009$) with a higher percentage of lighter women (94 vs. 47%) warming up for every event than heavier women.

The majority of athletes (71%, n = 94) practiced their competition warm-ups as part of their normal training. Differences that approached significance were observed for competition standard with a higher percentage of high-level amateur athletes practicing competition warm-ups (84%) as part of their normal training than local/regional-level athletes (65%) and international-level athletes (57%).

Athletes generally reported not using PAP (64%, n = 84) or passive warm-up techniques (77%, n = 101) as part of their warm-up. Athletes (23%, n = 31) that stated they used passive warm-up techniques on the competition day or before competition provided information on the type of strategies they used. The most common strategies used were as follows: warm-up creams, saunas or spas, hot baths or showers, heated pads or heated car seats, car heaters, and clothing (e.g., compression garments and warm clothing).

Strategies Used in the Warm-up

Strongman athletes reported what types of strategies they used to monitor exercise intensity during the warm-up. A summary of these responses is presented in Figure 1. The rate of perceived exertion (RPE), perceived speed of movement, and training load (as a % 1RM) were the most common types of monitoring of exercise intensity during the warm-up. "Other" types of strategies included answers associated with warming up by feel (e.g., mobility/range of motion, ease of movement, and energetic preparedness).

Strongman athletes reported what types of strategies they used in their warm-up. The strategies reported by strongman athletes were as follows: dynamic stretching (78%), foam rolling (68%), myofascial release work (62%), static stretching (52%), sports massage (27%), and other (13%). "Other" types of strategies included the following: muscle activation drills, breathing techniques, soft tissue mobilization tools, and traction. Note: As the athletes were able to list multiple types of strategies to this question, the sum of the percentages exceeds 100%.

Activities Performed After Warm-up

Strongman athletes reported what types of activities they performed after completion of the warm-up. Walk around (79%),

Table 3

Competition warm-up characteristics of strongman athletes (n = 132).*†

		Sex		Body mass				Age		Competitive standard		
				Males (n = 98)		Females (n = 34)						
	All strongman athletes (n = 132)	Male (n = 98)	Female (n = 34)	≤105 kg (n = 43)	>105 kg (n = 55)	<80 kg (n = 17)	≥80 kg (n = 17)	≤30 y (n = 51)	>30 y (n = 81)	Local/regional amateur (n = 34)	High-level amateur (n = 61)	International level (n = 37)
Warm-up for every event												
Yes	73 (55%)	49 (50%)	24 (71%)	19 (44%)	30 (55%)	16 (94%)	8 (47%)	27 (53%)	46 (57%)	14 (41%)	35 (57%)	24 (65%)
Sometimes	34 (26%)	29 (30%)	5 (15%)	13 (30%)	16 (29%)	1 (6%)	4 (24%)	13 (25%)	21 (26%)	14 (41%)	15 (25%)	5 (14%)
No	24 (18%)	19 (19%)	5 (15%)	10 (23%)	9 (16%)	0 (0%)	5 (29%)	10 (20%)	14 (17%)	6 (18%)	11 (18%)	7 (19%)
						9.47‡ 2§ p = 0.009‖						
Use PAP												
Yes	46 (35%)	36 (37%)	10 (29%)	19 (44%)	17 (31%)	6 (35%)	4 (24%)	20 (39%)	26 (32%)	11 (32%)	21 (34%)	14 (38%)
No	84 (64%)	61 (62%)	23 (68%)	23 (53%)	38 (69%)	10 (59%)	13 (76%)	30 (63%)	54 (67%)	23 (68%)	40 (66%)	21 (57%)
Use passive warm-ups												
Yes	28 (21%)	24 (24%)	4 (12%)	8 (19%)	16 (29%)	3 (18%)	1 (6%)	15 (29%)	13 (16%)	6 (18%)	15 (25%)	7 (19%)
No	101 (77%)	71 (72%)	30 (88%)	32 (60%)	39 (71%)	14 (82%)	16 (94%)	34 (67%)	67 (83%)	27 (79%)	46 (75%)	28 (76%)
Practice competition warm-ups												
Yes	94 (71%)	71 (72%)	23 (68%)	28 (65%)	43 (78%)	10 (59%)	13 (76%)	34 (67%)	60 (74%)	22 (65%)	51 (84%)	21 (57%)
No	34 (26%)	25 (26%)	9 (26%)	13 (30%)	12 (22%)	5 (29%)	4 (24%)	15 (29%)	19 (23%)	12 (35%)	9 (15%)	13 (35%)
											12.50‡ 4§ p = 0.014‖	

*PAP = postactivation potentiation.

†The results are expressed in 2 ways, with the first value being the total number of occurrences and the second number (in parentheses) the percentage of total occurrence. Discrepancies appear for subject numbers when data were not reported by strongman athletes.

‡Chi-square value.

§Degrees of freedom.

‖p value.

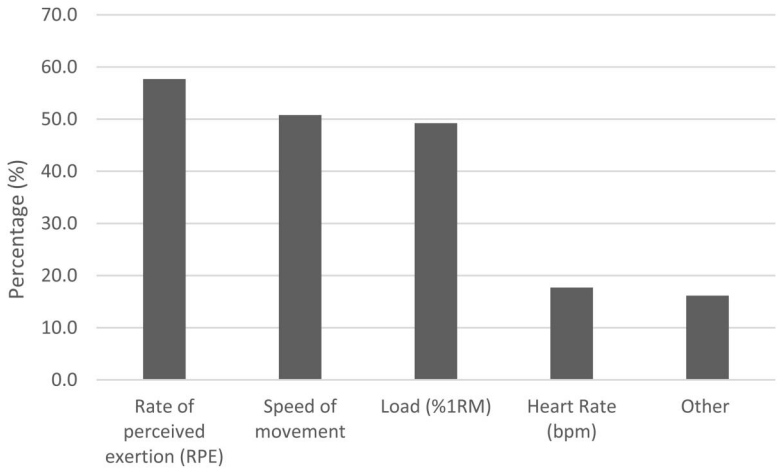

Figure 1. Types of strategies used by strongman athletes to monitor exercise intensity during the warm-up. As the athletes were able to list multiple types of strategies to this question, the sum of the percentages exceeds 100%.

listen to music (46%), sit down (44%), put on a tracksuit (18%), and other (9%) were the types of activities performed. "Other" types of activities included visualization of events, eat food and drink fluids, lie down, keep warm and mobile, and talk to people. Note: As the athletes were able to list multiple types of activities to this question, the sum of the percentages exceeds 100%.

Event-Specific Warm-up

Strongman athletes reported average warm-up information for the farmers' walk, log lift/press, and stone lifts/work events (Table 4). Significance between exercise differences ($p < 0.001$) was observed among the 3 strongman events for the number of warm-up sets performed. A significant difference ($p < 0.001$) was also observed between the log lift/press and stone lift/work with a higher number of repetitions typically performed in the log lift (2.8 ± 1.1 vs. 1.9 ± 1.4). No statistical differences were observed between loads used (%1RM) and rest periods used between sets.

Why Warm-ups Have Not Worked

Strongman athletes were asked to specify when warm-ups have not worked, what went wrong, and why. A summary of their responses is presented in Table 5. Lack of time or time warming up, time between warm-up, and event and logistical issues were the most common themes reported by strongman athletes.

Recovery Between Warm-up and Event

Strongman athletes were asked had there been any circumstances that affected their recovery time between the end of their warm-up and the start of their event/s. Almost half of the strongman athletes (46%) reported that there were circumstances that affected their recovery time. The most common issues reported were unexpected changes (i.e., the event started earlier or later than expected), logistical issues (i.e., number of competitors, order of competitors, and event planning issues), temperature (i.e., extreme hot or cold), dehydration, and mental stress/distractions.

Cognitive Strategies

Strongman athletes reported what they felt they needed to do regarding psych arousal level to improve strongman competition performance. Athletes generally reported that they needed to increase (56%) or maintain (36%) psych arousal levels. The most common themes reported by strongman athletes were immediately increase psych arousal before lifting and stay calm and collected when not lifting to conserve energy. Athletes who chose "other" reported that they increased and reduced psych arousal levels throughout the day and psych arousal levels depended on the event.

Strongman athletes reported numbers on a psych-up level scale (with 1 being totally relaxed to 10 being totally psyched-up), which they believed was best for their optimal strongman competition performance. Most athletes reported numbers at the higher end of the scale, with "8" being the most commonly reported number. Athletes provided comments on their psych

Table 4

Strongman athletes reported average warm-up information for the farmers' walk, log lift/press, and stone lifts/work events.*

	Farmers' walk ($n = 100$)	Log lift/press ($n = 100$)	Stone lifts/work ($n = 100$)
No. of warm-up sets	2.7 ± 1.0†‡	3.8 ± 1.2†	2.2 ± 1.3
Distance (m)§ or repetitions per set	9.4 ± 7.3 m	2.8 ± 1.1†	1.9 ± 1.4
Load used (as a%1RM)	66.6 ± 11.1	68.8 ± 10.0	68.8 ± 10.0
Rest period between sets (min)	3.4 ± 1.5	3.3 ± 1.3	3.5 ± 2.4

*%1RM = percentage of 1 repetition maximum.
†Significantly ($p < 0.001$) different to log lift/press.
‡Significantly ($p < 0.001$) different to tone lifts/work.
§For the farmers' walk, a number of athletes ($n = 37$) did not specify an actual distance covered in a set. Instead, most of these athletes stated their warm-up distances were half of the specified competition distance (60%, $n = 22$). Eleven athletes stated their warm-up distance was the full length of the specified farmers walk event.

Table 5

Why warm-ups have not worked (n = 81).*

Higher-order themes	Responses	Selected raw data representing responses to this question
Lack of time or time warming up	33	"Not enough notice to start warming up. Not enough sets done." "Not enough time to warm-up due to time and number of people that need to warm-up." "Distractions can cut warm-ups short or make them otherwise incomplete."
Time between warm-up and event	18	"Too much time between warm-up and event starting." "I was either cooled down or not recovered by the event start because I started either too early or too late on warm-ups."
Logistical issues†	17	"Contest warm-ups are very limited, and often we don't have sufficient time to be fully prepared, or we have to share the same log for warm-ups with many other athletes." "There are some competitions that do not allow the exact implement to be used in the warm-up." "If the space for the competition is so limited that there is nowhere and no equipment to warm-up, as happens sometimes in big convention centers like at the Olympia." "No adjustable implements."
Over exertion	13	"Tired myself out with too much in my warm-up." "Went too heavy and too long." "Jumps too big weight wise."
Technique/Injury	10	"Lack of equipment, space or time—led to body being poorly prepared and injured my back." "I have had warm-ups on deadlifts go wrong. Usually I am forgetting to focus on an important cue like bracing." "Did warm rear delts and tore bicep on axle clean."
Mental preparedness	8	"In the cases where warm-ups haven't worked, there may have been an underlying injury, or the mind wasn't in the right state (not focused, worried about other competitors, feeling sick)." "As long as there is time, space, and equipment available, most often a lack of focus caused by a suboptimal emotional state is the culprit in my experience."
Cold weather	2	"If very cold outside, no adjustable implements, not enough time."
Miscellaneous	14	"Buildup of fatigue from weeks prior." "I choose wrong exercises." "To be honest I barely warm up. I make it realistic to competition. The truth is you don't know if a warm-up is guaranteed."

*N.B. In some cases, the subject provided information that represented more than 1 concept and their response contributed to more than 1 higher-order theme.
†Logistical issues refer to equipment availability and access, warm-up space, and the number of athletes competing.

arousal levels. The most common themes reported by athletes were as follows: psych arousal was vitally important for successful competition performance, but too much psych arousal can lead to losing focus, poor technique, and increased risk of injury.

Strongman athletes were asked to indicate their use of each cognitive strategies (i.e., always use, sometimes use, or never use) before strongman competition events. A summary of these responses is reported in Figure 2. The most common cognitive strategies always used by most strongman athletes were attentional control, goal setting, mental imagery, preparatory arousal, emotional control, and positive self-talk.

Nutritional Strategies

Strongman athletes were asked to indicate their use of nutritional strategies associated with the competition day. A summary of these responses is reported in Table 6. The most common nutrition strategies used by strongman athletes included a focus on carbohydrate intake (i.e., the use of simple sugars, fruit, high carbohydrate meals/snacks, glucose tablets, and pre-event carbohydrate loading), specific meal characteristics (i.e., easily digested foods, high energy foods, eating between events, eat when hungry, preloading, liquid form, small and regular, and preprepared snacks/meals), protein intake (i.e., protein bars, protein shakes, and high protein intake), and fluid and electrolyte intake.

Supplements and Substance Use

Strongman athletes were asked to indicate which supplements/substances they generally use on the competition day. A summary of their responses is reported in Figure 3. Electrolyte drinks, caffeine, and preworkout supplements were used by most athletes. Athletes who chose "other" reported using glucose drinks, tablets or powder, whey protein drinks or powder, and intraworkout supplements.

Additional Information Given by Strongman Athletes

Strongman athletes were asked whether there was any additional information on their competition-day preparation that they would like to add. A summary of their responses is presented in Table 7. Other strategies, nutrition/hydration/supplements, and equipment/clothing were the most common themes reported.

Discussion

The literature on competition-day preparation strategies used by strength athletes is limited. The current study is the first to document the competition-day preparation strategies used by strongman athletes. Most strongman athletes indicated that they

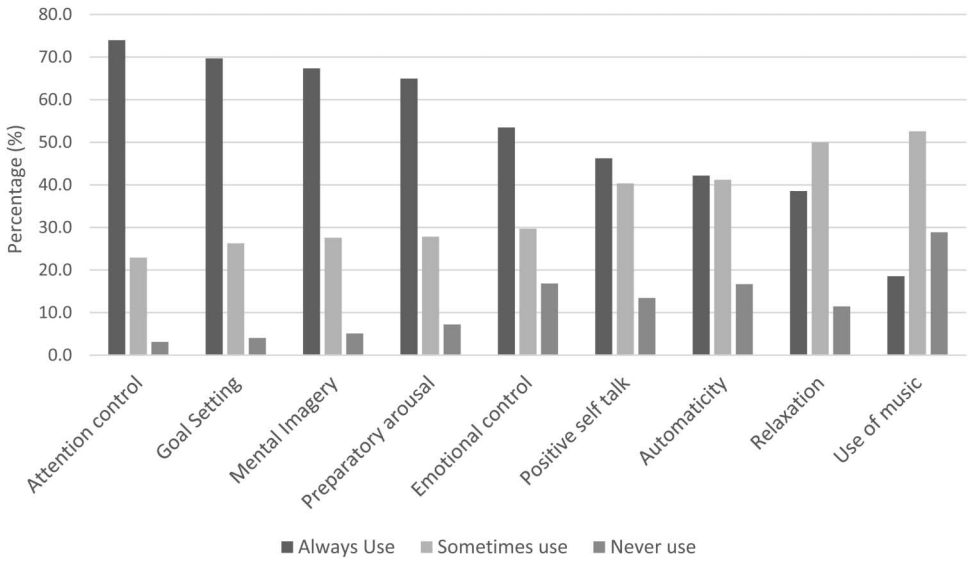

Figure 2. Indication of the types of cognitive strategies used by strongman athletes before strongman competition events.

used a warm-up (average length 16.9 ± 8.9 minutes) in strongman competitions and that their warm-ups were self-directed. The 3 main reasons for warming up were injury prevention, to increase activation, and increase blood flow/circulation, temperature, and heart rate. Most athletes practiced their competition warm-ups as part of their normal training, and warm-ups were event-specific. RPE, speed of movement, and training load (as a % 1RM) were the most common methods used to monitor warm-up intensity, and dynamic stretching, foam rolling, and myofascial release work were common types of strategies used in the warm-up. Most strongman athletes reported that they needed to increase or maintain psych arousal levels for competition and used a range of cognitive strategies with attentional control, goal setting, mental imagery, preparatory arousal, and emotional control, being the most common. Nutritional and supplement strategies were used by the most strongman athletes. The findings support the initial hypothesis that most strongman athletes responding to the online survey performed specific warm-ups before strongman events and used cognitive and nutritional strategies to improve competition performance.

Ninety-four percent of strongman athletes indicated that they used a warm-up in strongman competitions, and the typical warm-up length was 16 ± 8.9 minutes. Researchers have suggested that a warm-up for improving short-term performance in aerobic (running, cycling, and swimming) and team sports (football and rugby) should be approximately 10–20 minutes with an exercise intensity below 60% $\dot{V}O_2max$ (4), or if less than 15-minutes, the warm-up should have an aerobic portion with the inclusion of 4–5 activation race/event pace efforts (33). Such warm-ups are likely to cause minimal phosphate depletion, maximize the increase in muscle temperature, and significantly improve short-term performance (4). Further research is needed to investigate the effectiveness of different types of strength-specific warm-ups for the strength sports and how these may differ to the recommendations for aerobic and team sports.

The main reasons strongman athletes reported for warming up were injury prevention, to increase activation, and to increase blood flow/circulation, temperature, and heart rate. Researchers have demonstrated that warm-ups can reduce the risk of injury (6,57), increase muscle temperature (36), and neuromuscular function (39,40) and stimulate changes in the mechanisms underlying both anaerobic and aerobic metabolism (8,26). Muscle temperature–related mechanisms associated with the warm-up may have the strongest associations with performance improvements. Researchers have demonstrated that a 1° C increase in muscle temperature enhances subsequent performance by 2–5%, depending on the type and velocity of contractions (3,39,42), with the magnitude of muscle temperature response being positively related to movement velocity (42). However, if central temperature increases too high, this positive relation ceases and performance becomes impaired (42). The potential for overheating may be a particular concern in strongman, especially for competitors in the heavyweight classes when competing in hot and humid conditions (1).

In the current study, only 23% (n = 31) of strongman athletes used passive warm-up techniques. Such a result is surprising considering that passive warm-up techniques have been shown to improve dynamic force of short to intermediate duration (<10 seconds–5 minutes) (5). It may be that some passive warm-up techniques (i.e., hot showers, baths, and saunas) may be impractical for most of these athletes (5). Passive warm-up techniques such as warm-up creams and heating pads may be more useful especially in colder competition environments to help athletes better prepare for the active warm-up. It may be useful for strongman athletes to use heating pads between the end of the warm-up and the competition event (i.e., recovery duration). Researchers have shown significant improvements in sprint cycling peak (increased 9.6%) and relative power output (increased 9.1%) compared with the control group when heating pads were worn during the recovery duration (12).

The length of the recovery duration is important to optimize competition performance. The recovery duration needs to be long enough (>5 minutes) for the resysnthesis of PCr stores (9) and short enough (<15 minutes) so that muscle temperature does not drop significantly (41). Strongman athletes in this study fell within this optimal duration, reporting that 8.5 ± 4.3 minutes

Table 6

Nutritional strategies used throughout strongman competition (n = 107).*

Higher-order themes	Responses	Select raw data representing responses to this question
Carbohydrate intake	83	"Eat some simple sugars between events (i.e., gummy worms/sugary candy or fruit)." "Fruit is my go-to on day of competition." "Focus on a steady supply of small, easily digested doses of simple and complex carbs." "Glucose tablets after every event." "Carb loading the night before." "Easy digesting carbs and protein."
Meal characteristics	83	"During a long contest I will snack on light, easily digestible foods." "Lots of food." "Hydrate with water, consume small quantities of protein (usually whey isolate) and carbs (banana, granola bar, powder, etc.) between events if time allows and my stomach is agreeable." "Generally just aim to eat whatever keeps hunger at bay" "I can't stand the feeling of food in my stomach when I train or compete, so I make sure to have liquid calories with me." "Eat regularly small amounts."
Protein intake	61	"Protein bar if I feel hungry." "I like easy to digest foods and my protein drink." "I go with a high carb, high protein meals on comp days."
Fluid and electrolyte intake	32	"Lots of sodium and fluids." "Electrolytes, such as sodium, will help keep nervous system and muscles firing." "I sip on an electrolyte/carbohydrate drink throughout the day."
Fat intake	16	"Avoid fatty foods that will sit heavy in your stomach (I often have eggs for breakfast, but never on contest day, as I always throw them up)." "Usually a high carb, moderate protein and low-fat meal" "Keep my fats and carbs high."
Miscellaneous	29	"I struggle to keep food down" "My normal daily meals are the same" "This varies for each event. Some events can happen on a full stomach and some would make a mess."

*N.B. In some cases, the subject provided information that represented more than 1 concept and their response contributed to more than 1 higher-order theme.

was the optimal mean time between the end of competition warm-up and subsequent strongman event. This time period may likely provide the greatest ergogenic effect on their strongman performance.

Interestingly, the majority of strongman athletes (64%) reported not using PAP techniques as part of their warm-up. Postactivation potentiation refers to the phenomena in which muscle characteristics are acutely enhanced as a result of previous

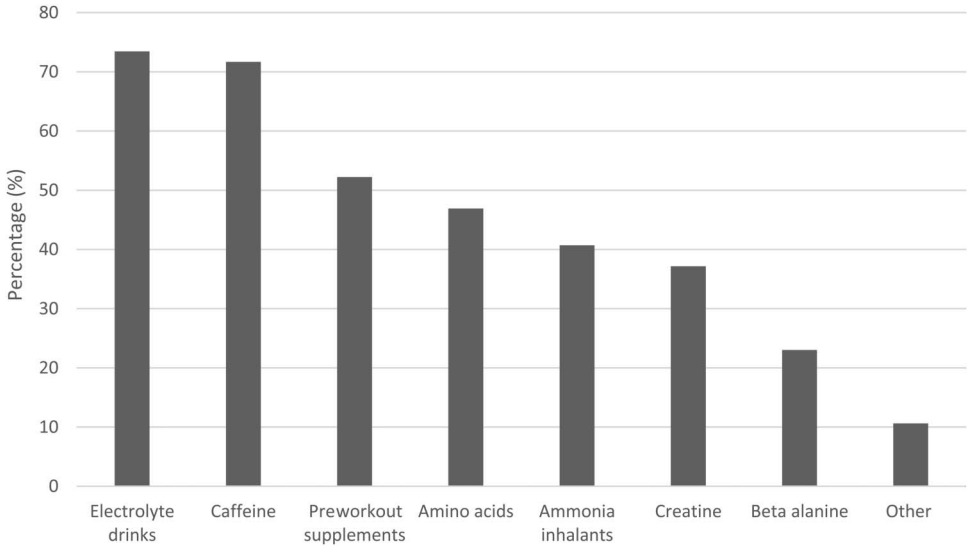

Figure 3. Types of supplements/substances strongman athletes generally use on the competition day. As the athletes were able to list multiple types of strategies to this question, the sum of the percentages exceeds 100%.

Table 7
Additional information given by strongman athletes (n = 37).*

Higher-order themes	Responses	Selected raw data representing responses to this question
Other strategies	10	"At larger events I use noise-cancelling headphones to relax and regroup. It is a great break from all the loud cheering and event noise."
		"A comfy fold up chair could be useful. Having a crappy place to sit between events could be detrimental physically and mentally."
		"Bring a friend, coach or family member to keep you in the game. Someone that will tell you what it is up and not what you want to hear."
		"Always have a physio handy, it is good to strap up any tender or sore muscles before events."
Nutrition/hydration/supplements	8	"I have a decent sized breakfast that focuses on protein and fat with some carbs as well to keep me satiated throughout the first event."
		"I make sure I drink an extra gallon of water the day before. With electrolyte powder mixed in to ensure I'm well hydrated."
		"I never drink coffee, but the competition day this is the first. My breakfast is ham or bacon."
		"Coffee right up to the beginning of the show...pre-workout after 1–2 events."
Equipment/clothing	6	"It's very important to have all your equipment and support gear ready and prepped and know right where it is and when you'll need it. Stress and rushing on event day is toxic."
		"Clothing is usually loose fitting and a number of layers. Usually a compression type base layer on bottoms, with shorts and track bottoms over the top."
Sleep	4	"Early night and have a min of 8 h sleep before comp."
Energy conservation	4	"Save your energy for the competition."
		"I minimize my energy expenditure between events"
Sun protection	2	"Sun protection is important for outdoor events, I like to have glasses, hat, and sunblock ready."
Miscellaneous	10	"I think everyone is different, there is no cookie cutter method to be successful. Use trial and error to you find a method that works for you that allows you to obtain your goals."
		"The biggest barriers on the day include: Long wait times between events, the length of a competition day performing maximally - weaker as the day goes on."
		"Most of this at a high level is dictated by the needs of the competitor at that moment."

*N.B. In some cases, the subject provided information that represented more than 1 concept and their response contributed to more than 1 higher-order theme.

voluntary contractions (47). Although research has demonstrated that it is possible to enhance mechanical power and performance of an explosive activity using PAP (47), research is needed to establish how the mechanisms of PAP and fatigue interact under different conditions before athletes can effectively apply PAP to improving acute strongman competitive performance.

Strongman athletes reported that they used RPE, speed of movement, and training load (as a %1RM) as ways of monitoring their exercise intensity during the warm-up. Researchers have demonstrated that RPE is a reliable method to quantify various intensities of resistance training (10). Interestingly, relatively few athletes (18%) reported using heart rate as a way of monitoring warm-up intensity. Although heart rate is a common method of monitoring exercise intensities during endurance training (16), heart rate has been described as a relatively poor method of evaluating high-intensity exercise such as resistance training (13). Rate of perceived exertion, speed of movement, and training load may be more valid strategies for strongman athletes for quantitating warm-up intensity for various strongman events.

Most strongman athletes reported using dynamic stretching, foam rolling, and myofascial release work as part of their warm-up strategy. Researchers have demonstrated that these strategies are effective for improving range of motion and joint mobility (2,35), which may be beneficial for strongman events such as the log lift and stone lift. Although the effect of these strategies on performance is not clear, such strategies may help reduce the feeling of postexercise fatigue (23) and relieve acute sensations of muscle tightness, which may be beneficial for strongman athletes competing in a number of events over long time periods.

In the current study, 81% of strongman athletes reported that they warmed up, or sometimes warmed up, for every strongman event during a single competition. Although no literature has investigated repeated competition warm-ups among the strength sports (i.e., strongman, Highland Games, weightlifting, and powerlifting), the use of half-time re–warm-up strategies has been shown to enhance performance parameters in soccer players (11,60). Given the longer rest times between events and the technical aspects and loads associated with strongman competition events, re–warming up and practicing the specific movement patterns of each event may provide further ergogenic benefits by priming neural pathways and increasing neuromuscular activation (15).

Differences in warm-up were observed among the farmers' walk (2.7 ± 1.0), log lift/press (3.8 ± 1.2), and stone lift/work (2.2 ± 1.3) for the number of sets performed and between the log lift/press and stone lift/work (2.8 ± 1.1 vs. 1.9 ± 1.4) for the number of repetitions performed. Such differences may give insight into the unique technical and physiological demands of each strongman event (58) and the preparation needed for each event. Strongman athletes reported that warm-ups can also be influenced by a number of factors including the amount of time given to warm-up, logistics (i.e., number of competitors, space/venue, how the competition and

events are planned, and implement types i.e., adjustable/nonadjustable), and temperature (i.e., extreme hot or cold).

Although warm-ups physiologically prepare athletes, they also provide valuable time for athletes to mentally prepare (psych-up) for competition and allow athletes to obtain the appropriate activation state (5). Psyching up has been defined as the use of self-directed cognitive strategies designed to enhance physical performance (49). Most strongman athletes in this study reported that they needed to increase or maintain psych arousal levels. Athletes reported that psych arousal was vital for successful competition performance and needed to be immediately increased before lifting and decreased when not lifting to conserve energy. Conversely, athletes reported that too much psych arousal can lead to losing focus, poor technique, and increased risk of injury.

Strongman athletes identified the most common cognitive strategies always used were attentional control, goal setting, mental imagery, preparatory arousal, emotional control, and positive self-talk. These cognitive strategies were reported to be used by the US Olympians in practice and competition and were reported to enhance the display of muscular strength (45). Such findings suggest that strongman athletes use a number of effective cognitive strategies to optimize strongman competition performance.

Nutritional strategies were also used by strongman athletes to optimize strongman competition performance. One of the most important factors to optimize competition performance through nutrition is to ensure caloric intake offsets energy expenditure (31). Meeting caloric needs may be difficult for strongman athletes who are engaged in intense physical activities over prolonged periods. It has been recommended that athletes who are involved in high-volume intense training need greater amounts of carbohydrate (complex carbohydrates and concentrated carbohydrate drinks/supplements) and protein in their diet to meet macronutrient needs (29). The use of carbohydrates before, during, and in-between events may enhance carbohydrate availability (46), whereas protein can be beneficial for increasing the rates of protein synthesis, decreasing the rate of protein degradation, and improve recovery from exercise (29).

In addition to ensuring appropriate carbohydrate availability throughout the day (46), it is also critical that athletes consume a sufficient amount of water or sports drinks (containing glucose and electrolytes) during exercise to maintain hydration status (29). The amount of hydration needed can be influenced by temperature, humidity, exercise intensity, and the athletes' sweat response to exercise (32). Based on the high body mass and body mass to surface area ratio of heavier strongman athletes, strongman competitors may require large intakes of water or sports drinks when competing in hot and humid environments.

Stimulants such as caffeine and pre-orkout drinks were reported to be commonly used supplements by strongman athletes. Preworkout drinks contain a combination of key ingredients such as creatine monohydrate, amino acids, betaine, selected botanicals and plant extracts, carbohydrates, and caffeine, which may elicit a synergistic effect on acute exercise performance and subsequent training adaptations compared with single ingredients alone (24). A review of caffeine and sports performance by Goldstein et al. (17) found that caffeine enhanced several different modes of exercise performance including endurance, high-intensity team-sport activity, and strength-power performance; however, its effect on sport performance can be influenced by the condition of the athlete and the intensity, duration, and mode of exercise. Caffeine is also commonly used and accepted among athletes for its ability to promote wakefulness, enhance focus and concentration, and to prevent the central perception of fatigue (27). Given the unique and physiological demands strongman athletes endure on the competition day, it is quite likely strongman athletes use these supplements as strategies to positively affect cognitive and physical performances.

Practical Applications

This article serves as the first comprehensive description of the competition-day preparation strategies strongman athletes use. The information in the current study will serve to help strongman athletes, strength athletes, coaches, and sports scientists in achieving the optimum physiological and cognitive states for competition.

To warm-up successfully, strongman athletes should perform event-specific warm-ups between 15 and 20 minutes to increase blood flow, temperature, heart rate, and muscular activation. The use of dynamic stretching, foam rolling, and myofascial release work can be included in the warm-up to assist mobility. Strongman athletes should also complete a number of progressively heavier sets of the upcoming strongman event to practice the specific techniques required in the upcoming event and to have the appropriate level of psych arousal. Rate of perceived exertion, perceived speed of movement, and training load (as a %1RM) can be used to monitor warm-up intensity.

It is recommended that athletes use a number of cognitive strategies including attentional control, goal setting, mental imagery, preparatory arousal, emotional control, and positive self-talk to enhance strength performance. The use of caffeine or preworkout drinks may help improve cognitive function and exercise performance.

Caloric intake needs to offset energy expenditure and eating carbohydrates and proteins before, during, and in-between events may enhance carbohydrate availability and assist in the improved recovery from exercise. Temperature, humidity, exercise intensity, and sweat response to exercise will influence an athlete's hydration status and, consuming sufficient amounts of water or sports drinks throughout the competition day may help to maintain hydration status.

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