Coaches' philosophies on the transfer of strength training to elite sports performance

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Abstract

The objective of the study was to explore coaches' philosophies regarding strength training (repetitive muscle actions against high loads) and the transfer of strength training to sports performance. Thirteen world class coaches and athletes from track cycling, BMX, sprint kayaking, rowing and athletics sprinting were interviewed using an open-ended, semi-structured approach. Participants were asked about their coaching philosophies, design of athlete training programmes, strength training and its transfer to sports performance. A thematic analysis was conducted. Data trustworthiness was enhanced by methods of member checking and analyst triangulation. Coaches believed that task-specific strength is essential for sports performance. They reported that non-specific strength training ("traditional" gym-based strength exercises that are not specific to a sport movement) is important for increasing athletes' muscle size and strength. This is typically used in conjunction with resisted sport movement training (for example, increased resistance running, pedalling or rowing), believed to achieve an effective transfer of enhanced muscle strength to sports performance. Coaches described the transfer process as complex, with factors associated with fatigue and coordination having particular significance. The importance that coaches place on coordination is supported by a theoretical model that demonstrates increases in muscle strength from strength training may need to be accompanied with a change in inter-muscular coordination to improve sport performance. The idea that each athlete needs to adapt intermuscular coordination in response to a change in his/her unique set of "organism constraints" (e.g. muscle strength) is well described by the theory of ecological dynamics and Newell's model of constraints.

Keywords

Resistance training, coordination, specificity, experiential knowledge, qualitative methods, maximal effort

Introduction

Coaches of sports requiring maximal effort over a short period of time (<60 s), such as track sprint cycling, sprint kayaking (200 m), and sprinting (athletics) often consider strength training (repetitive muscle actions against high loads) to be a fundamental aspect of an athlete's training programme [1]. Accordingly, sprint athletes from a range of sports routinely undertake strength training in addition to sport-specific training [1,2]

Despite the common prescription of strength training in elite sport, empirical evidence shows that transfer to sports performance varies[3,4]. Generally, there is positive transfer to sports performance; for example Blazevich and Jenkins found strength training improved 20 m start time in elite junior sprinters [5]. However, sometimes there is no effect or even a negative transfer (i.e. strength training is detrimental to performance) [3,4]. Moir and colleagues found a similar strength training intervention worsened 20 m acceleration time in an equivalent cohort of athletes[6].

Strength training increases muscle strength and size[3,7], so the focus of non-specific strength training ("traditional" gym-based strength exercises that are not specific to the sport movement e.g. squat, deadlift, and leg press) is often on these muscular adaptations[8]. It also causes neural adaptations such as recruitment, or more consistent recruitment, of the highest threshold motor units, increased motor unit firing rates, and an increase in tendency of motor units to fire synchronously, collectively referred to as intramuscular coordination[3,7,9]. These neuromuscular adaptations are well correlated with performance in high-intensity locomotive sports (e.g. sprint cycling, running, kayaking and rowing). The maximum power of elite sprint cyclists, for example, is strongly correlated with maximal torque, which in turn, is correlated with lean leg volume [10]. 'Gym strength' (assessed by the amount of mass that can be lifted in a non-specific strength exercise - measured in this example by the isometric mid-thigh pull) has also been correlated with sprint cycling power and sprint cycling times[11]. Similar relationships between determinants of strength and sports performance have been found for sprinting and rowing[12,13].

Despite beneficial neuromuscular adaptations, some whole-body mechanisms such as inter-muscular coordination may explain the reduction in performance sometimes associated with strength training. Inter-muscular coordination could influence the transfer of strength training to sport performance in two ways. First, increases in muscle strength from strength training may need to be accompanied with a change in inter-muscular coordination to improve sport performance. This idea was supported by Bobbert et al. who showed that an increase in leg strength must be accompanied by a change in intermuscular coordination in order for vertical jump height to increase[14]. This idea that the coordination patterns need to change in response to changing constraints (e.g. muscle strength) is captured by key ideas in ecological dynamics and Newell's model of constraints[15]. Newell proposed that patterns of coordination emerge from the constraints imposed on an individual during action. Constraints are boundaries or features that shape the organisation of emergent coordination patterns[15].Accordingly, strength training may be expected to change the individual constraints of each athlete by changing muscle strength, body segment parameters, muscle fatigue, and intramuscular coordination. Second, muscle recruitment patterns associated with a strength training task could retard sports performance when expressed during the sport movement[3]. For example, the strength training programme of a sprint cyclist commonly consists of non-specific strength training exercises, such as squats, deadlifts and leg presses[2]. These exercises, however, have very different inter-muscular coordination patterns compared to the act of pedalling[16]. In this way, extensive non-specific strength training could impair pedalling coordination such that cycling performance is reduced. This notion is further supported by the training principle of specificity, which states that the closer the strength training resembles a sport movement, the greater the transfer of strength, particularly in elite athletes[4,7].

Our motivation for conducting this study was simple. Before we engaged in a more positivistic programme of research to examine how to integrate strength training with that of coordination training, we wanted to understand current beliefs, existing knowledge and ideas that underpinned elite coaches' approaches to the idea of integration. In essence, this is what we considered to be the 'philosophy' behind the day-to-day practice of elite coaches' design of strength and conditioning and coordination training in sports like cycling[17].

Elite coaches and athletes are highly motivated, and have years of experience to evolve and improve their training protocols to achieve successful transfer of strength training to sports performance. This group’s philosophies may, therefore, be regarded as current ‘best practice’. Here, a qualitative approach was chosen to enable exploration of coaches’ experiential knowledge and insights, an approach used previously in sport science research to provide insights to enhance understanding for empirical and applied research[18-20]. Also there is very little information in the literature about elite coaches’ approaches to strength training and sports performance. A selection of sports demanding maximal effort over a short period of time were chosen for analysis as there are clear parallels between sports, and so coaches’ experiences can be synthesized. The aim of this study, therefore, was to explore elite coaches’ philosophies regarding strength training and the range of factors and ideas believed to affect transfer of strength training to sport performance.

Methods

Thirteen participants (12 male and 1 female) were recruited by purposive (criterion-based) sampling [21], the criteria was that the participants were elite coaches or athletes in the sports of track sprint cycling, BMX, sprint kayaking, rowing and athletics sprinting. The participants were composed of 11 elite coaches and 2 athletes.. The coaches all worked at international level and coached either the development (3) or senior squads (5), with some specialising in strength and conditioning (3). Coaching experience ranged from 2.5 to 31 years. Six of the coaches had prepared athletes for the Olympic Games, with five having coached Olympic medallists. Both athletes were Olympic medallists who had competed at international level for over 12 years. Participants were recruited through a high performance sport network and a regional elite sports club, and were provided with the details of the study and signed the consent form. The study was approved by the Sheffield Hallam University Faculty of Health and Wellbeing Research Ethics Sub-Committee.

To address our research aim we adopted the combination of epistemological constructionism and ontological relativism to inform a post-positivism research paradigm[22]. The interviews were semi-structured with open-ended questions to allow participants to express thoughts and expand on topics[22]. The list of questions that formed the interview framework started with general warm-up questions on sport background and experience, moving to more specific questions asking about coaching philosophy, athlete attributes, design of training programmes, strength training, and the transfer of strength training to sports performance. Probing questions were used to obtain more detail[22]. A pilot interview was conducted to assess question suitability. All interviews were conducted by the primary researcher and took place at the participant's place of work. Interviews were between 19 and 55 minutes in length (mean 34 minutes), and were recorded on a digital voice recorder.

The interviews were transcribed verbatim and small grammatical changes were made to improve the flow of the text. To enhance data trustworthiness a process of member checking was carried out[23]. For this process, transcripts were sent to participants to check for accuracy, correctness of researcher interpretations and for clarification on any transcript passages where the meaning was unclear.

The primary researcher undertook an initial analysis and coding of the transcripts using inductive reasoning in the software programme NVivo (QSR NVivo 10). This approach allowed the primary researcher to identify emerging data saturation. Following the 11th interview, a decline in new information was observed. After the 13th interview theoretical saturation was identified as all new data fitted into the existing organisation system without the emergence of new themes[24].

A thematic analysis was conducted[21,22]. Data were initially coded into raw themes, which were grouped into lower and higher order themes. Themes were reworked and refined by repeatedly reviewing generated themes, and the original data. Another method used to enhance output trustworthiness was analyst triangulation[24]. A second researcher analysed a sample of the interview transcripts independently and discussed themes generated with the research team before final themes were agreed.

Results

Key themes emerging from interview data were grouped into ‘strength training’, and ‘transfer of strength training to sports performance’ (Figure 1, Figure 2). Transcripts revealed 30 initial data nodes, further grouped into higher and lower order themes. Coaches’ philosophies were similar, although key areas where viewpoints differed included quantity and scheduling of training sessions.

Strength Training

Coaches believed that non-specific strength training was important for increasing athletes’ muscle size and strength (Figure 1). The key role of non-specific strength training was muscle-level adaptations, typically in isolation from sports performance, as highlighted by the following coaches:

> *“Bigger muscles are generally stronger muscles, so the first part of our preseason is about muscle mass not typical hypertrophy ….. we want size but we also want strength as well. So it's obviously it is heavy weights ... it's our philosophy that size is one of the biggest contributors towards how strong the muscle will be.”* P5 – Coach

> *“We are in the gym for hypertrophy and muscle mass, basically building a bigger stronger muscle.”* P7 – Coach

Participants also stated that an athlete’s expression of strength needs to be specific to their sport:

"Strength for an [athlete] is different to strength in the gym, because it is task specific." P4 – S&C coach

"[We need] explosive power, but we need the base of strength first, and then that needs to be synchronised with the art of pedalling." P5 - Coach

During preseason training the coaches' focus was increasing the athletes' muscle size and strength; therefore, non-specific strength training was prioritised in training programmes, as this coach expresses:

"Generally at the start of [the pre-season] …. the athletes would be in the gym three times a week and … [have sport-specific training] probably twice a week which is maintenance really." P5 - Coach

However, during the competitive season the aim was to maintain the athletes' strength by reducing the number and volume of gym sessions, but maintaining intensity, as one of the strength and conditioning coaches highlighted:

"So for [gym sessions close to competition] dropping volume, maintaining intensity ….. and including some …. slightly more dynamic efforts" P1 – S&C coach

Coaches typically talked of prescribing non-specific strength training exercises in gym sessions, for example squat, leg press, deadlift, bench press:

"Being an upper body sport: bench press, bench pull, chin up [which] would be ….. in any kayak programme from club to international level." P1 – S&C coach

“From a gym strength side of things, we have standards for the big core lifts, so things like, squat, deadlift, trap bar deadlift.” P4 – S&C coach

“Preferably most of [the strength training] is done in the gym using primary movements: squat, deadlift, cleans, leg press.” P10 - Coach

When increased specificity was desired, rather than trying to make the gym exercises more sport-specific - i.e. by mirroring the sport movement patterns, coaches instead preferred to add resistance to sporting movements. Examples of resisted sporting movements would be resisted rowing, resisted running, or over-geared (increased resistance) pedalling:

“Parachute or a bucket off the boat so they would still be doing resisted work but it would be in the context of rowing.” P2 - Coach

“Resistance running – hills …. [and] sledge work at the right time though I don't do any more than 20m in a rep with sleds and I don't put too much weight on either.” P13 - Coach

Coaches believed that this resisted sport movement training transferred quicker than non-specific strength training exercises, as they included similar movement patterns to the sport. Accordingly, these sessions were used as a bridge between the non-specific strength training and sports performance as this coach describes:

“So for a couple of those athletes the gym structure would be anywhere between two or three sessions a week in a heavy gym, heavy strength block with some [resisted movement training] as well to encourage as much crossover as we can in that period.” P9 – Coach

Only two participants included gym exercises that were sport-specific as they thought the coordination aspects transferred:

> *"There are some athletes that are doing slightly more similar exercises like RDL's [Romanian deadlifts] or the first pull of a clean off the floor which are very similar [to the sports movement], and I do think there is some transfer and there is coordination aspects of that which are really useful."* P8 – S&C coach

In contrast, as highlighted by the following quote for most of the participants the role of gym sessions is to increase muscle size and strength, and sport-specific training for improving explosivity and coordination:

> *"I think my views and my philosophies …… have changed over time…. and a years ago I would have had a stronger … view on training in a different way where it was more strength based, and then the gym exercises ….changed after the strength period to be light and explosive and lifted rapidly….. Whereas now …. we aim for strength and size from the gym, but the importance of the bike in the equation is so much higher which really makes sense when you think about it, and so that coordination and the explosivity that you want …we just get on the bike and so we manipulate the volume of that work and what it looks like in the training week, .. rather than try and go and get it in the gym."* P5 - Coach

[Insert Figure 1.]

Figure 1: Strength training: lower and higher order themes

(Number of expert sources in brackets)

Transfer of strength training to sports performance

Participants believed that the transfer of strength training to sports performance was not as simple as athletes getting stronger in the gym then immediately getting quicker at their sport (Figure 2). Therefore, they did not believe there was a direct correlation between 'gym strength' and sports performance, and that sometimes increased 'gym strength' did not transfer to performance speed at all, as one athlete discussed:

> *"I have known athletes that can lift a lot more in the gym but are slower on the [track] so it leads me to think for me there is not necessarily a direct correlation, although for some people there is. One of the guys that I am coaching it seems to be that he has had a quite linear progression in the gym in terms of his 1RM, squat 1RM and it seems to translate directly to the [track] without any period of adaption at all."* P12 – Athlete

Coaches identified several training protocols, athlete attributes and factors that they thought affected the transfer effectiveness and the length of the transfer period (Figure 2). Including speed and technique sessions during a non-specific strength training phase was one of the training protocols coaches thought improved transfer:

> *"So in the spring period we would add into the weights part of the programme some maximal bouts of sprint work on the rowing machine in order to make sure gym work is relevant to a more rowing specific movement."* P3 - Coach

“For a couple of those athletes …… in a heavy gym, heavy strength block include maybe it’s a style of warm-up or what we would call a recovery session on the bike, we should have a little speed element or a little bit of acceleration in there with a general fitness underlying thing. So we are still keeping relatively fit, there is still a little bit of pedalling and speed work in there but the aim is getting stronger.” P9 - Coach

One factor affecting transfer of strength training was fatigue generated from a period of heavy strength training, which meant that an ensuing recovery period was required to observe performance benefits as a coach proposed:

“I don't think you see any [immediate] transfer at all because of the amount of fatigue that the strength places the athlete under. However, where you do see the benefits is when you freshen them up, that’s when you see the reward.” P3 - Coach

Participants also highlighted sports technique as being an important factor for transfer:

“We have already talked about that the influence of technique. I have seen a lot of people who have got more strength and have never got anything on the water, so it is not just a long time scale; it is almost if there is something extra that has to come with having the increase in strength. Even in the most specific exercises we have in gym, the transfer is far from the given, so it can be time poorly invested if you cannot put it down at all.” P2 - Athlete

“So, your technique needs to adapt, to go with your strength, is that it?” Interviewer

"Yeah, exactly, both in terms of movement speed and coordination." P2 - Athlete

Participants also believed that speed and technique training sessions were needed in an athlete's training programme to maintain technical performance during a period where non-specific strength training was prioritised, and these sessions facilitated a quicker transfer of 'gym strength' to sports performance:

"So if we took an athlete and said "Right, we need you to get stronger we are going to spend the whole year trying to get you stronger" …. and that's possible to do with almost any athlete. But … if we weren't teaching them…. [movement] dynamics …. or speed…. potentially they just get slower from being stronger." P10- Coach

Coaches also believed that the transfer period from increased 'gym strength' to improved sports performance was individual and could be lengthy as these two coaches expressed:

"I do think there is a lot of individual response, particularly in elite athletes who are fundamentally different to most populations you would be able to test on." P4 – S&C coach

"It's a fairly long transition [from non-specific strength training to improved sport performance] and there has definitely been periods where we have got athletes stronger but not quicker and there have definitely been periods where we have got an athlete quicker but not any stronger." P9 - Coach

[insert Figure 2.]

Figure 2: Transfer of strength training to sports performance: lower and higher order themes

(Number of expert sources in brackets)

Discussion

Here we examined the philosophy and ideology behind strength training in elite performance programmes in sports demanding maximal effort over a short period of time. Our main findings suggest that coaches viewed task-specific strength as important for sports performance, and that this is typically achieved with a combination of non-specific strength training and resisted sport movement training.

The coaches' rationale for including non-specific strength training in the athletes' programmes was predicated on muscle-level adaptations, increasing muscle size and strength, a notion clearly supported in the scientific literature as key adaptations to strength training[3,7,25]. Muscle size and strength have been correlated with sports performance in maximal sports, further supporting the coaches' philosophy[10,26]. A few participants specifically mentioned using strength training to achieve neural adaptations which typically improve rate of force development, important in explosive sports (that require high acceleration from the start)[27,28]. Despite strength training having been shown to lead to other adaptations which contribute to increased muscle strength, such as changes to muscle-tendon stiffness and compliance, tendon properties[29] and muscle architectural changes [30], the coaches did not specially refer to these adaptations.

Only a few coaches applied the training principle of specificity when selecting and designing gym exercises, contrasting with some previous literature stating that specificity of the strength training needs to increase for elite athletes to keep improving sports performance[4,7,31]. Coaches chose gym exercises to increase strength of muscles required for the sport movements. However, coaches supplemented these exercises with resisted movement training, by using the sport movement with added resistance, to achieve specificity of load. This approach has been suggested in the literature as a method for achieving specificity[4,32].

Coaches perceived that there was not a direct correlation between increased ‘gym strength’ and improved sporting performance. This view slightly contradicts their view that non-specific strength training is important for improving an athletes’ strength. However, they acknowledged that the transfer of strength training to sports performance is not inevitable and that the correct training protocols (for example by including speed and technique sessions during a strength training block) are required to achieve a successful transfer of strength. The belief that there is no direct correlation between increased ‘gym strength’ and improved sporting performance concurs with previous findings showing that transfer of strength training to sports performance can vary[3,4]. Coaches identified the key factors that they considered to influence transfer. Specifically, they highlighted that a period of rest or reduced training load to is required to reduce fatigue and thus enhance the benefit from strength training, a notion which is supported in the literature[7,33].

Coaches also considered the role of coordination in the transfer process as they believed that it was important to maintain an athlete’s sport technique (sport-specific coordination and movement patterns) and speed during a strength training period. In agreement with this idea, some researchers consider that coordination has an important role in achieving successful transfer of strength training to sports performance[3,31]. Carroll et al, for example proposed that inter-muscular coordination has a role to play in training transfer, suggesting that negative transfer may occur if the inter-muscular coordination patterns of the training task retard sport specific performance[3]. Beyond aspects of training specificity, however, some researchers have suggested that inter-muscular coordination may also be the mechanism to explain the timeframe – as identified by the coaches in the present investigation – between increased strength and enhanced sports performance. Bobbert et al., for example, used a musculoskeletal simulation to demonstrate that an increase in leg strength must be accompanied by a change in intermuscular coordination in order for vertical jump height to increase[14]. The idea that each athlete needs to adapt intermuscular coordination in response to a change in his/her unique set of “organismic constraints” (e.g. muscle strength) in an individualised way is very well described by the theory of ecological dynamics and Newell’s model of constraints[15]. The associated period of inter-muscular coordination adaptation may, therefore, explain the timeframe associated with a successful transfer of strength training to sports performance, as highlighted by the coaches in the present study.

This study added to the literature examining experiential knowledge, beliefs and understanding of a sample of elite coaches in high performance sport. Further empirical research is needed to determine the relative importance of each factor identified by the coaches that affect transfer of strength training to sports performance to inform coaching practice. This would allow the development of a theoretical framework on how best to combine the benefits of non-specific strength training, which causes muscle-level adaptations, with sport-specific training that improves coordination and technical ability to perform a sport movement. The participants for this study were all recruited from sports that require maximal effort over a short period of time, which involve a cyclical action (for example stroke in rowing and kayaking, stride in running and crank revolution in pedalling) and are relatively closed skills sports. Therefore, it is not clear whether the findings may be applicable to understanding training for other sports, such as team games which contain more open skills, despite the requirement for maximal bursts of effort. These maximal bursts of effort in team sports are intermittently repeated throughout a whole competitive match, which differs from the sports in this study which require one all-out effort by an athlete.

Conclusion

The main findings are that coaches view task-specific strength as important for sports performance, and that this is best achieved with a combination of non-specific strength training and resisted sport movement training. The transfer of strength training to sports performance was believed to be a complex process, with factors associated with fatigue and coordination having particular importance. The importance the coaches' place on coordination is supported by a theoretical model that demonstrates increases in muscle strength from strength training may need to be accompanied with a change in inter-muscular coordination to improve sport performance[14]. The idea that each athlete needs to adapt intermuscular coordination in response to a change in his/her unique set of "organism constraints" (e.g. muscle strength) is well described by the theory of ecological dynamics and Newell's model of constraints[15].

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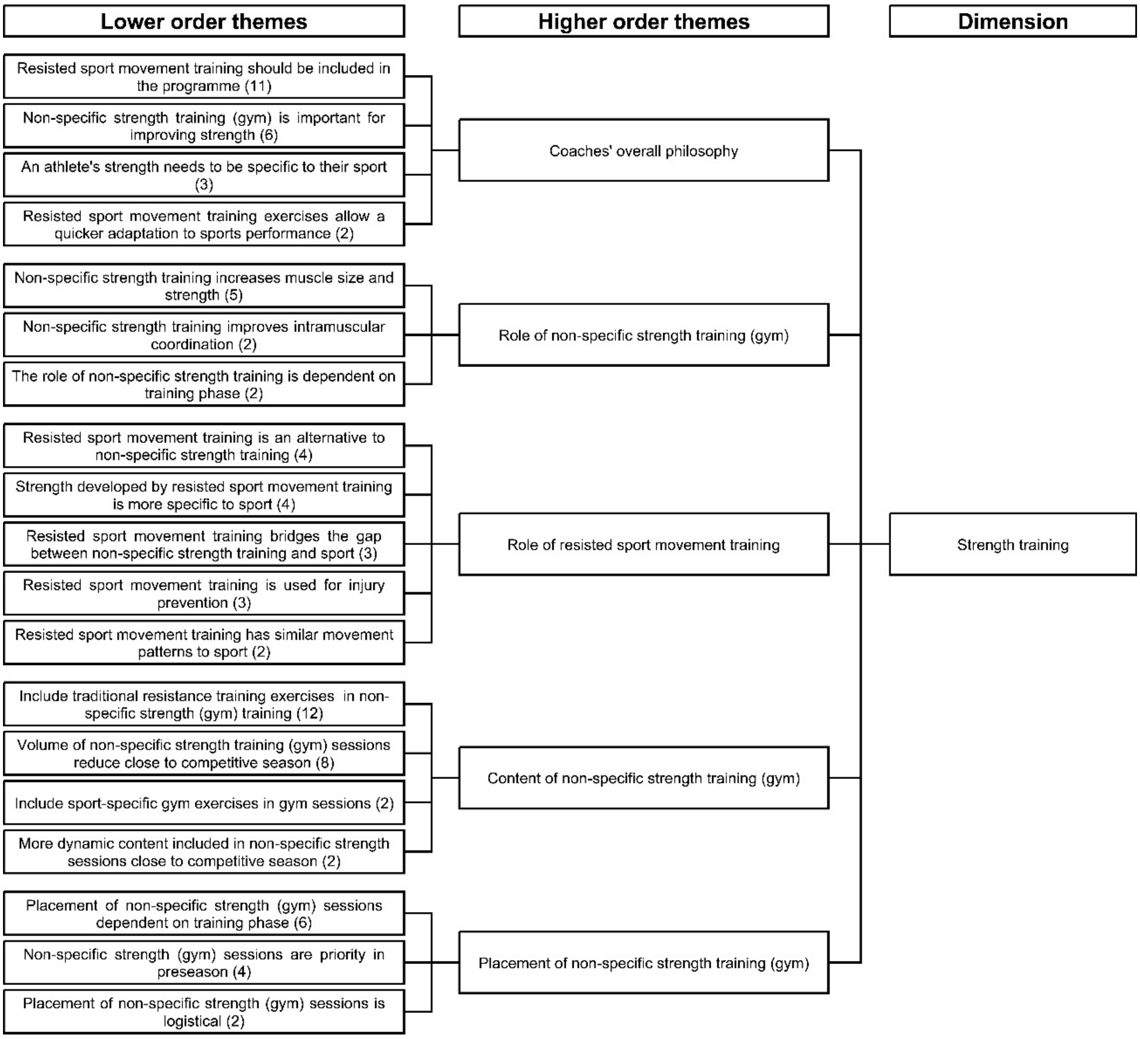

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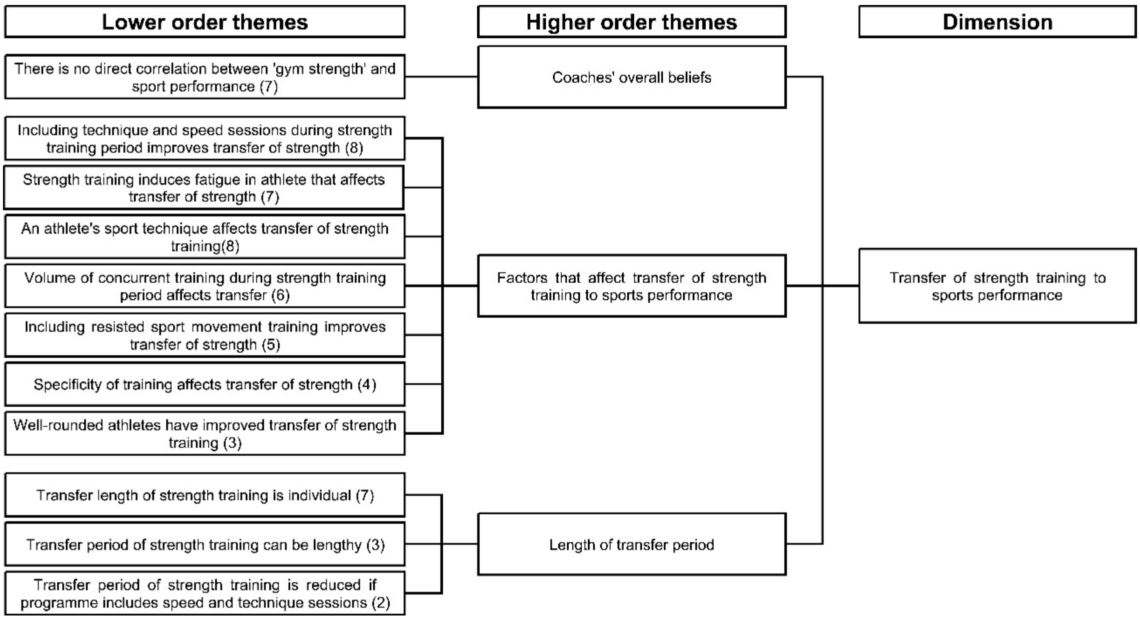

Figure 4: Transfer of strength training to sports performance: lower and higher order themes

(Number of expert sources in brackets)