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ORIGINAL RESEARCH

Influences of a yoga intervention on the postural skills of the Italian short track speed skating team

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Introduction: In preparation for a short track speed skating season, eight men and seven women were given yoga sessions during an 8-week high volume training cycle. The sessions were planned according to the postural aspects specific to short track speed skating technical requirements. Three specific goals were selected for the intervention: 1) to observe whether the practice of yoga as postural training could improve the efficiency and the athlete's repertoire along the muscular synergies solicited in the short track speed skating specific technique; 2) to enhance and diversify the motor time-on-task of athletes without changing the prescription of other training stimulus; and 3) to lower the risk of injury during periods with high volumes of training.

Methods: A total of 36 sessions of yoga were given. Three postural tests were administered before and after the intervention with 14 angles analyzed. Non-parametric Wilcoxon test was used to compare angles' variations.

Results: The 36 yoga sessions totalized 986 minutes of motor time-on-task, registering a proportion of 30% of the global motor time-on-task of the training cycle. Improvements were found in eleven of the 14 angles measured when comparing pre- and post-postural tests (*P*-value from 0.01 to 0.005). During the 8 weeks, excepting traumatic injuries due to short track speed skating accidents, no skaters suffered injuries linked to the high volume of training. Following the intervention, coaches noticed, following their on-ice feedbacks, an adjustment in the efficiency of the skating technique, in particular regarding hip dissociation.

Conclusion: These results suggest that yoga could be inserted into out-of-season training cycles, even in a high volume training cycle. Planned with the decision training tools, it allows athletes to diversify their motor time-on-task by integrating a new functional range of generic movements with the solicitation of neuromuscular synergies related to the specificity of their sport.

Keywords: conditioning, motor time-on-task, physical literacy, athletic development, decision training

Introduction

Context of the intervention

In the modern era of professional and Olympic sports, every sport has a strong market culture. To achieve the highest levels, athletes, coaches, and other leaders must be rigorous and demonstrate their foresight in their way of trying to meet the demands of the market in which they find themselves. Therefore, the overall performance of an athlete or of a group of athletes requires the interaction of several factors presenting first, within each specific sports market, a dichotomy: what emanates from the body and the capacities of the athlete, the endogenous factors, and what comes from

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outside to influence and stimulate the athlete, the exogenous factors. Then, the technical factors, each time along with the internal logic of the market, are also influencing the nature of the motor skills the athletes are required to perform. As this article stages the Italian short track speed skating team, Table 1 lists the technical factors both endogenous and exogenous which influence a high level athlete evolving within the short track speed skating world cup circuit.[1]

Thus, we can resume by saying that short track speed skating requires the combination of having a proper end efficient skating technique, power in the lower limbs, stamina, and a strategy repertoire in a race situation. To bring their athletes to their top performance, coaches should first position themselves regarding influencing factors and will then be able to understand the many interactions, such as illustrated in Figure 1.[1]

Motor skills are split into three categories: locomotor activities, manipulation activities, and postural activities.[2] Short track speed skating is mainly a locomotor activity but the efficiency of this locomotor action requires a specific posture, and because of its technical requirements, the basic position of speed skating, being itself a global muscle synergy, demands significant postural adjustments. In order to have an efficient skating technique, the athlete must take into account the positioning of his trunk tilted forward, the positioning of his hips, of his shoulders as well as the efficiency of his leg's extension and balance during both the push and recovery movements, as well as the cross-over and the pivot in the turns.[3,4]

The present article depicts 8 weeks of summer training of the Italian national speed skating short track team. Two years away from the 2014 Sochi Olympics, the coaches were examining how to organize their out-of-season annual training program. According to them, the global culture of short track speed skating causes each of the competing countries to carry out many sessions on the ice in the

Table 1 Influencing factors on the short track speed skating athlete's performance

Technical factors	Endogenous factors	Exogenous factors
Skate	Psychological dispositions	Values of the coaches, executives, clubs, federations
The speed skating boot	Family history	Relevance of selected training stimuli
Blade supports	Sporting history	Training partners
The blade:	Relationship history	The skating technique taught
Metal type	Lifestyle	Physical preparation
Rocker angle	Available support	Training results and follow-up
Curve angle	Physical qualities	Athlete's nutritional program
Sharpening quality	Weight	Quality of sleep
Clothing technology	Height	Athlete's social and academic life
Suit type	Morphologic type	Psychological performance preparation
Textile fiber type	Muscle fiber quality	Opponents
Training suit versus competition suit	Physiological dispositions	Perceived post-athletic life situation
Hand protection	Motor qualities	
Eye protection	Global motor repertoire	
Head protection	Short track speed skating	
Environment	specific motor skills	
Safety, quality, and properties of the ice	Perception of the skating technique's	
Protection mattress	specific of the body schematic:	
Place of training	Shoulder position	
Place of competition	Hip position	
	Knee position	
	Ankle position	
	Range and efficiency of the skating	
	step, cross-over and pivot	
	Efficiency of both legs	
	Racing experiences:	
	Starting technique	
	Track knowledge	
	Passing strategies	
	Energy management	
	Strategic positioning	
	Trial by error and success	

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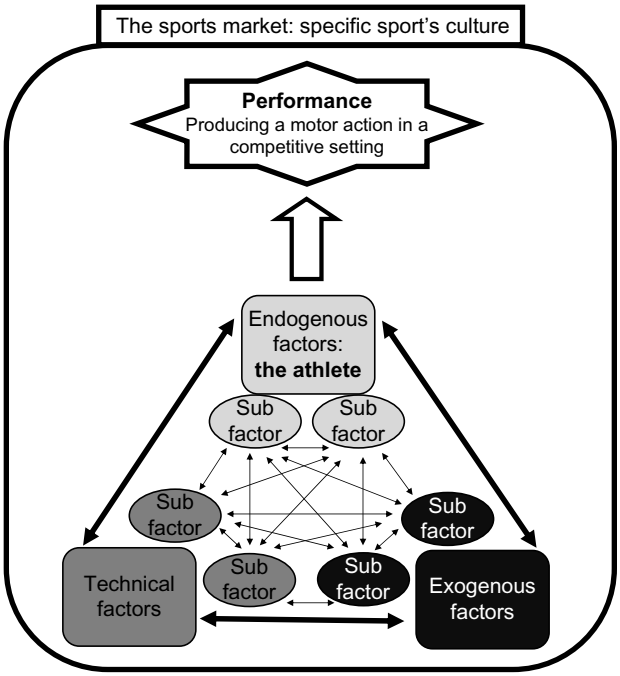

Figure 1 Interactions between endogenous, exogenous, and technical factors influencing performance on a sports market.
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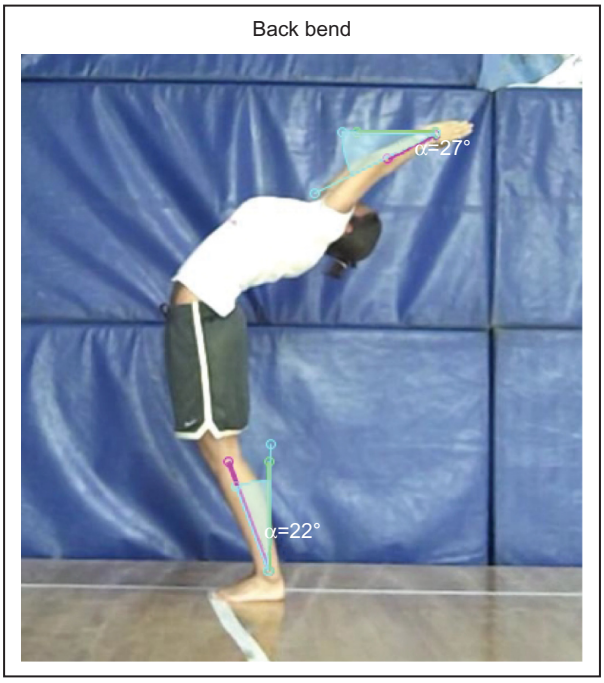

Figure 2 Example of back bend.

course of training. As a matter of fact, two daily sessions on the ice is standard during summer training camp, allowing the athletes to increase the amount of laps in between two seasons of competition.

The increase of the amount of laps in the summer creates significant stress for the adaptation in this specific posture, to such an extent that it can interfere with other training activities. Coaches had noticed that during these increases in training volume, it sometimes became difficult to obtain quality work during off-ice workout sessions, running sessions, core muscle strengthening exercises, as well as sometimes on the ice.

In order to counter this specific problem, the research team decided to make the choice of a training stimulation that potentially had the opposite effect; while the athlete's body adapts to drive the high volume of the specific postures of short track speed skating, what if at the same time, it has to develop a new postural skill: yoga. With this situation, adding yoga sessions fits this need because of its postural nature. This activity, based on knowledge that has been passed down for millennia, offers its practitioners, in a wide range of styles, the execution of a series of postures and breathing exercises.[5]

Research on the benefits of yoga is a growing field.[6–9] Many sciences and areas of interest are studying its effects. Reviews of literature and narrative synthesis abound, all pointing in the same direction. It appears that yoga has the potential to improve many psychological, physiological, and motor factors, and this, for an eclectic list of conditions: stress and anxiety,[10–14] many psychiatrics conditions,[11,15–19] low back pain,[15,17,20] diabetes and body weight outcomes,[21–23] cancer,[24,25] cardiac health,[26] hypertension,[27,28] pulmonary conditions,[28] etc. Despite these positive feasible outcomes, research requires more rigorous protocols to seal scientifically valid benefits, including great methodologies for clinical trials and the whole pedagogical issue in the perspective of the intention to treat.

Even though yoga is a popular trend in professional sports, less is known in the scientific literature about its real effects in the matter of strength and conditioning for elite athletes. However, many studies indicate the avenues of exploration: 24 yoga sessions through 8 weeks of Bikram yoga improves strength of the lower limbs;[29] measured with kinematic, kinetic, and biomechanical data, Hatha yoga postures showed that they can engender an appreciable range of joint angles through the ankle, knee, and hip, and elicited a qualitative rectus abdominis activity.[30] The effects on flexibility are also noticed in many positives ways, as well as the delayed onset of muscle soreness in the lower extremity.[31,32] It has also been shown that yoga "asanas" are effective in teaching musculoskeletal anatomy of the lower limbs.[33]

In this context, coaches decided to add yoga sessions for 8 weeks in a prospective study (which corresponded to

two training camps separated by a week of rest for the entire team) to the original training plan, to achieve three objectives: 1) to observe whether the addition of the practice of yoga as postural training could improve the efficiency and the athlete's repertoire along with the muscular synergies solicited in the short track speed skating specific technique; 2) to enhance and diversify the motor time-on-task of athletes without changing the prescription of other training stimulations; and 3) to lower the risk of injury during periods with high volumes of training.

To achieve these objectives, the coaches made the hypothesis that adding a training stimulation related to the postural skills, here in the form of yoga customized for short track speed skating, would produce a positive effect in the athlete's physical literacy, and ultimately, this positive effect would be transferred to their specific task. The concept of physical literacy can be defined, as appropriate to each individual's endowment, as a disposition to capitalize on the human embodied capability, wherein the individual has the motivation, confidence, physical competence, knowledge, and understanding to value and take responsibility for maintaining purposeful physical pursuits or activities throughout the life course.[34]

Methods

Intervention calendar planning

Initially, the coaches had identified a reality: the volume of all the training stimuli already contained in the training plan could not be increased. In addition, these stimuli already covered the three main motor skills:[2] locomotion, handling and posture. Locomotion with skating, running, cycling and imitations; handling with bodybuilding; postural skills with stabilization drills and abdominal workout.

Then, in the context of the postural over adaptation in connection with the high volume of laps performed on ice, and with the understanding of the research team on important postural aspects to consider in the practice of short track speed skating, the work of the research team was to make a decision on the nature of the intervention. In the knowledge that comes from yoga, there are a wide variety of styles and a wide repertoire of positions, which lists more than 1,000 positions. In the planning, it was important that the choice of positions would meet the functional needs identified by coaches in relation to the technical requirements of the speed skating technique. The idea was to widen the base of the functional range for segments identified as key elements in the basic position: leg extension, balance and support, hip mobility, and shoulder positioning. In pursuing this objective, 85 positions were identified; these positions can be found in the pictures directory in Supplementary material 1.

During the 8 weeks, the training stimulation's allocation was planned as follows: 16 muscular workout sessions; 14 running or cycling sessions; 22 sessions of stabilization, imitation of skating movements and torso muscular training; and 62 sessions on the ice. Thirty-six yoga sessions were added to this already established plan, as summarized in Table 2. In total, 19 yoga stretch and 17 athletic yoga classes were

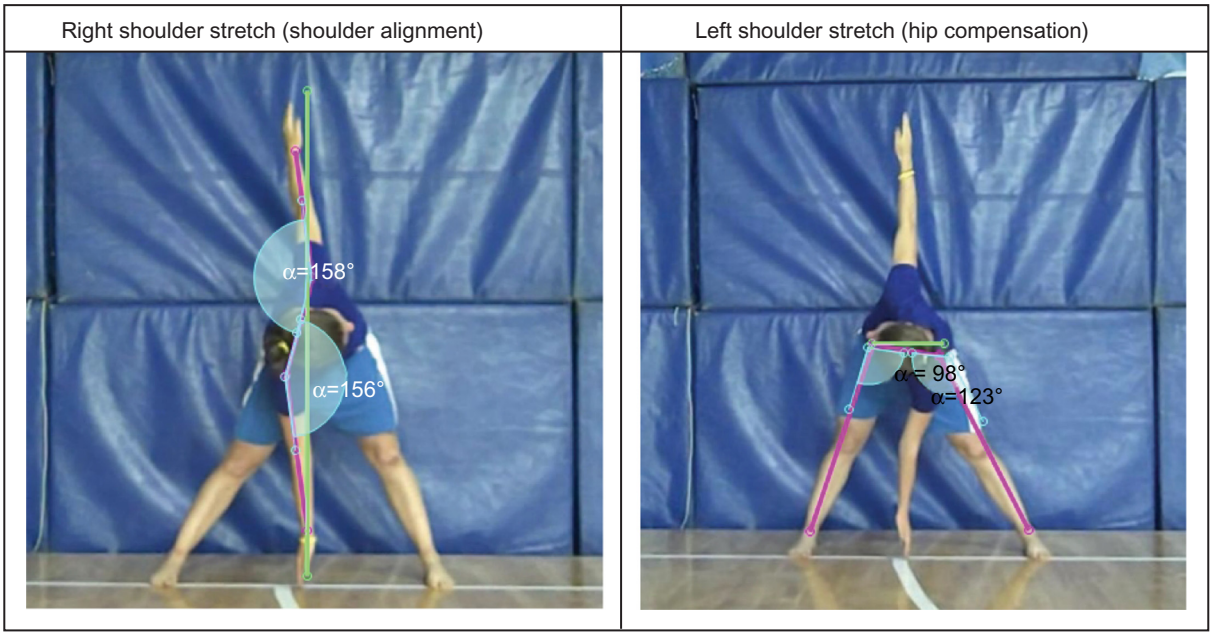

Figure 3 Example of the shoulder stretch.

Table 2 Yoga sessions added to the training calendar: July 2, 2012 to August 21, 2012

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
July 2 Afternoon: ice and **yoga stretch # 1**	3 Morning: ice and stabilization Afternoon: ice and **athletic yoga # 1**	4 Morning: ice and bodybuilding Afternoon: bike ride	5 Morning: ice and yoga athletic # 2 Afternoon: ice and abs workout	6 Morning: ice and bodybuilding Afternoon: ice and **yoga stretch # 2**	7 Morning: ice and imitations Afternoon: ice and abs workout	8 Day off
9 Morning: ice and run Afternoon: Ice and bodybuilding	10 Morning: ice and stabilization and abs workout Afternoon: ice and **athletic yoga # 3**	11 Morning: ice and bodybuilding Afternoon: bike ride	12 Morning: ice and abs workout Afternoon: ice and **athletic yoga # 4**	13 Morning: ice and bodybuilding Afternoon: ice and **yoga stretch # 3**	14 Morning: ice and imitations Afternoon: ice and abs workout	15 Day off
16 Morning: ice: individual testing Afternoon: ice: relay testing	17 Morning: ice and bodybuilding Afternoon: ice and **yoga athletic # 5**	18 Morning: ice and stabilization Afternoon: bike ride	19 Morning: ice and bodybuilding Afternoon: ice and **yoga athletic # 6**	20 Morning: ice and imitations Afternoon: ice and **yoga stretch # 4**	21 Rest	22 Rest
23 Rest	24 Rest	25 Rest	26 Rest	27 Rest	28 Rest	29 Rest
30 Afternoon: ice and **yoga stretch # 5**	31 Morning: ice and **yoga athletic # 7** Afternoon: ice and abs workout	August 1 Morning: ice and bodybuilding Afternoon: bike ride	2 Morning: ice and imitations Afternoon: **yoga stretch # 6** and ice and **yoga athletic # 8**	3 Morning: ice and bodybuilding Afternoon: run and abs workout	4 Morning: ice and **yoga athletic # 9** Afternoon: ice and **yoga stretch # 7**	5 Day off
6 Morning: ice and bodybuilding Afternoon: **yoga stretch # 8** and ice	7 Morning: **yoga stretch # 9** and ice and **yoga athletic # 10** Afternoon: ice and run	8 Morning: ice and bike ride Afternoon: **yoga stretch # 10** and bodybuilding	9 Morning: **yoga stretch # 11** and Ice Afternoon: ice and **yoga athletic # 11**	10 Morning: ice and bodybuilding Afternoon: run and **yoga stretch # 12**	11 Morning: **yoga stretch # 13** and ice and **yoga athletic # 12** Afternoon: ice and abs workout	12 Day off
13 Morning: ice and bodybuilding Afternoon: bike ride	14 Morning: **yoga stretch # 13** and ice **yoga athletic # 13** Afternoon: ice and run	15 Morning: ice and abs workout Afternoon: **yoga stretch # 14** and bodybuilding	16 Morning: **yoga stretch # 15** and ice and imitations Afternoon: ice and **yoga athletic # 14**	17 Morning: ice and bodybuilding Afternoon: run and **yoga stretch # 16**	18 Morning: ice and **yoga athletic # 15** Afternoon: **yoga stretch # 17** and Ice	19 Day off
20 Morning: ice: individual testing Afternoon: ice: relay testing	21 Morning: **yoga stretch # 18** and ice and bodybuilding Afternoon: ice and **yoga athletic # 16**	22 Morning: **yoga stretch # 19** ice and **yoga athletic # 17** Afternoon: bike ride	23 Rest	24 Rest	25 Rest	26 Rest

Abbreviation: abs, abdominal.

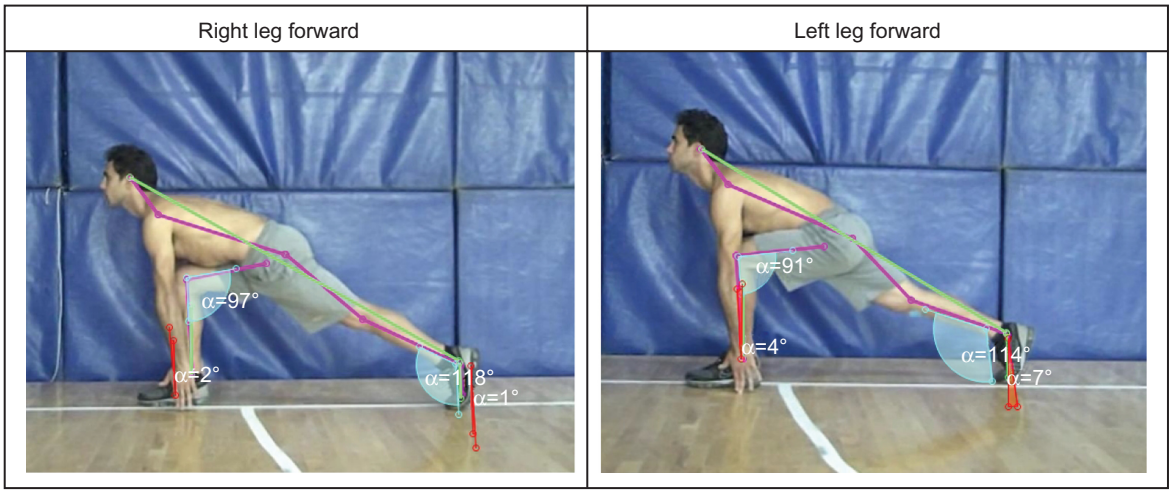

Figure 4 Example of runner's pose.

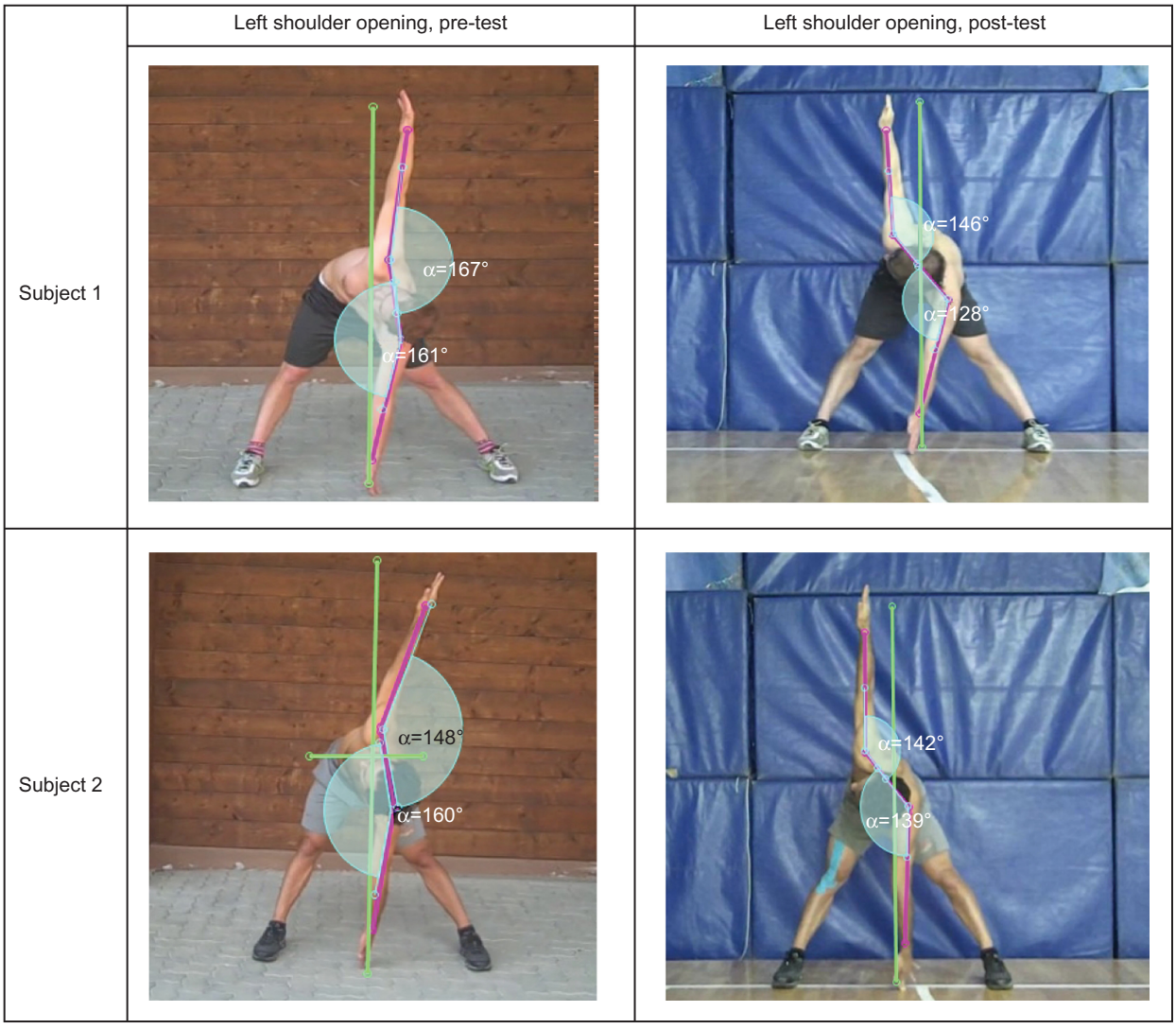

Figure 5 Two outlier observations in shoulder stretch.

added. The global planning of the annual training program is available in Supplementary material 2.

Intervention planning

Once the 85 positions were identified and the general planning was completed, the "decision training" approach was used to plan the learning sequence.[35] This planning method gives guidelines which place the athletes in an autonomous learning process with the aim to acquire new motor skills.[36] Out of seven, five of these guidelines were mainly used.

Hard skill task at the beginning of the intervention

In contrast to a progressive discovery from the simplest positions to the most complex, the athletes were exposed to the challenge that stood before them from the very first session, experimenting with positions with high technical requirements, for instance: yoga position # 30) the Bikram chair, # 35) the warrior tree, # 38) the bonsai, and # 39) the Bikram arrow.

A varied and random practice

The intervention structure was prepared in such a way that athletes did not receive the same session twice; the prescription of positions, the rhythm variations, and the order of the sequences were constantly renewed and adjusted to the improvements observed on the field. However, the duration of the sessions was very much the same with an average of 41 minutes.

Modeling

The modeling approach was adopted throughout the sessions. The yoga coach acted also as a strength and conditioning coach with the team, and had other daily tasks such as supervising warm-ups, bodybuilding, imitations, running training, and abdominal workouts. For theses yoga lessons, he showed, in real time, the postures to take, always with a sense of great execution, with the pleasure of reaching the technical requirements of each posture.

Bandwidth feedback

In conjunction to the "modeling" approach, the "decision training" approach to feedback commands a limited bandwidth: as long as the coach explicitly broadcasts his instructions, models the actions to reproduce, and can see that the athletes are attempting to do their task properly, he remains silent. Feedback is provided only if: 1) the coach finds that one or more athletes are not properly carrying out the given task or are not on a path to success; or 2) he finds that one or more athletes carry it out perfectly and takes advantage of the situation to reinforce modeling.

Questioning

If an athlete wanted to discuss the technical aspects of the yoga intervention, instead of giving the answer at hand, the coaching team replied by answering questions on internal feedback perceived by the athlete during the task. Also, at the end of each athletic yoga session, athletes were questioned as to how they had perceived the effort on Borg's scale,[37] by rating the day's effort from 1 to 10. The collected data can be found in Supplementary material 3.

Environment, atmosphere, and behaviors during yoga sessions

The sessions were held in large rooms. Each athlete had an open space to execute positions. Varied background music accompanied the demonstration of the yoga coach. During yoga activities, athletes were asked to remain silent, to focus on having a deep and regular breathing rhythm, and to pay attention to proper technical execution keys and feedback mentioned.

Participants

Fifteen athletes, seven women and eight men, took part in the 8 weeks of training. This sample is a sample of convenience since these athletes are selected and invited to the national team activities. Average age for women was 21.29±3.5 years and their experience on the world cup circuit was on average 4±2.7 competitive seasons on the national team. Average age for men was 22.75±3.28 years and their experience on the world cup circuit was on average 3±2.7 competitive seasons on the national team.

Table 3 Anthropometric measures before the intervention

	Height (cm)		Weight (kg)		Fat percentage		Kilograms of muscular mass		Muscular mass body percentage		Body mass index	
	Ladies	Men	Ladies	Men	Ladies	Men	Ladies	Men	Ladies	Men	Ladies	Men
Average	166.3	177.7	59	75.6	20.7	10.7	24.7	38.2	41.9	50.6	21.4	23.9
Standard deviation	3.3	8.1	4.3	7.1	2.4	2.4	1.7	3.0	1.3	1.7	23.9	1.2

As can be observed in Table 3, despite large standard deviations in size and weight in the women as well as in the men, attention should be paid to the small deviations in terms of body mass index, the body fat ratio as well as the muscle mass ratio to the weight in kilos. These similar ratios could be attributed to shared training stimulations, eating habits, and the annual training program experienced by the team over an extended period.

Fat percentage was measured with a Harpenden skinfold caliper and calculated with the seven folds method (subscapularis, pectoral, triceps, abdominal, pelvic, thigh, and calf). The team doctor administered the test and produced the report which can be found in Supplementary material 4.

Postural measurements

To measure the evolution of range of motion and body schematic perception, three postural tests were administered before and at the end of the intervention. The protocol of each of the three tests goes at follows: the athlete is asked to hold a specific position for 20 seconds. Execution keys are given explicitly, using anatomic references to guide the athlete. No feedback is given other than the execution keys. The 20-second sequences were filmed with an HD Flip Cam (Cisco Systems, Inc., San Jose, CA, USA). Stills from the clips were made using Sony Vegas software (Sony Creative Software Inc., Middleton, WI, USA), when the athlete showed the best form in the 20 seconds from the execution keys of each test. The angle processing was done using Kinovea software measurement tools (http://www.kinovea.org). This software performs processing angles with a margin of error of 1 degree. All processing of angles was done by a single person who was doubly blinded, both from the content of the research and its outcomes. The markers for the angles were identified manually by the software and some anatomical landmarks, as the anterior superior iliac spines are sometimes hidden by clothing.

Description of the postural tests

Back bend

General description

The back bend consists of, while standing, arms straight and hands joined together, bringing the shoulders as low as possible toward the back. This position shows the range of back and lumbar muscle movement (Figure 2).

Link with short track speed skating

This functional demonstration of the back is in complete opposition to the muscular synergy associated with the skater's basic position.

Test instructions

- Position preparation: standing with feet together, hallux and heel touching one another, stretch hands toward the sky, then "glue" them together, while keeping the arms extended with the least possible elbow flexion.
- Moving to the position: pull the chin out toward the sky, and with a controlled movement, push the hips toward the ground by contracting the gluteus without bending the knees, move shoulders toward the back and the ground at the same time as far as possible.

Analyzed angles

a. Back bend range of motion
   - Sky angle: this angle is the result of an angle between a segment parallel to the ground and a segment that passes through the olecranon and left of the center of the palm of the left hand.
   - Floor angle: this angle is the result of an angle between a segment perpendicular to the ground and a segment that passes through the lateral malleolus of the left foot and the lateral epicondyle of the left knee.

Angles' relation

The range of motion is shown in the relationship between the two angles: the greater the sky angle, the lower the score, and a greater amplitude corresponds to a higher score.

Shoulder stretch

General description

The shoulder stretch requires a muscular synergy stemming from the hips, a torso twist toward the alignment of the arms and chest, while the feet are placed as wide as possible on the ground (Figure 3).

Link with speed skating

While the legs are open the shoulder stretch position requires a dissociation of the hips and torso, in a movement that is typical of a skating stride.

Test instructions

- Place feet wide and parallel, toes and heels of each foot in the same direction.
- Touch the ground with one hand's middle finger, without putting any weight on it. Stretch the opposite hand toward the sky, while trying to form a line, as straight as possible, between the torso and both arms, without bending the knees.
- The athlete must perform this test twice, once on both sides.

Analyzed angles

a. Shoulders' alignment
   - Sky angle: this angle is the result of an angle between the segment that passes through the left and right acromion and acromion segment that passes through the sky acromion to the head of the radius of the arm outstretched to the sky.
   - Floor angle: this angle is the result of an angle between the segment that passes through the right and left acromion and the segment that passes through the acromion to the head of the radius of the arm outstretched to the ground.

Angles' relation

The closer the result of the addition of the two scores is to 180 (referring to 180 degrees), the more the shoulders and arms tend to form a vertical line.

b. Hips' alignment
   - Right hip: this angle is the result of an angle between a segment that passes through both anterior superior iliac spines and a segment that passes through the right anterior superior iliac spine to the malleolus.
   - Left hip: this angle is the result of an angle between a segment that passes through both anterior superior iliac spines and a segment that passes through the left anterior superior iliac spine to the malleolus.

Angles' relation

If the scores of the two measured angles are similar, it indicates that the compensation is small. If there is a big difference, we can identify which hip is compensating, the biggest result indicating the hip that pushes inward.

Runner's position

General description

The runner's position requires an important adjustment of the torso's muscle structure, caused mainly by the distance between the supporting leg and the back leg, which is fully extended (Figure 4). It requires a good distribution of balance because the hands cannot be used as a support despite the torso leaning forward.

Link with speed skating

This position combines many of the muscular qualities required for an efficient skating stride: a strong leg supporting a simultaneously extended "pushed out" leg. If the contraction of the torso muscles is not in harmony with the legs, it becomes difficult to spread out the feet and perform the test requirements.

Test instructions

- Place a supporting foot flat on the floor, and align its knee straight above the supporting ankle, with a 90 degree bend of the leg, placing the thigh at a horizontal angle as much as possible.
- Bring the other foot back as far as possible, while trying to keep the foot at a 90 degree angle compared to the ground, finding balance only with toes. Keep the back leg straight, especially at the knee.
- Then, lower the torso toward the front, until it is possible to touch the ground with the fingertips while keeping the arms straight; fingertips should only barely touch the ground.
- The athlete must perform this test twice, once on both sides.

Analyzed angles

- Supporting leg to ankle angle: this angle is the result of an angle between a segment from the lateral malleolus to the lateral knee condyle, and a segment perpendicular to the ground.
- Supporting leg to knee angle: this angle is the result of an angle between a segment which passes through the lateral malleolus of the ankle to the lateral epicondyle of the knee and a segment which passes through the lateral epicondyle of the knee to the femoral head.
- Balance foot to ankle angle: this angle is the result of an angle between a segment which passes through the lateral malleolus of the foot toward the metatarsal phalangeal joint of the big toe and a segment perpendicular to the ground.

Angles' relation

All angles' results show whether the athlete is able to accurately reproduce the commands of the test.

Motor time-on-task

Motor time-on-task for each planned activity was calculated. Taking into account the nature of each activity, various strategies were used for calculations. Supplementary material 5 brings together most of the elements at the basis of this compilation.

1. Muscular activity: planned actions, number of series, number of repetitions, and their prescribed execution tempo; number of active seconds.
2. Cycling and running activities: running and cycling minutes in real time for non-stop sessions, series, and the number of seconds for the planned volume. Also, the Polar Team[2] a heart rate monitoring tool (Polar Electro,

Kempele, Finland), was worn by the 15 athletes in several sessions, allowing collection of time data.

3. Stabilization, imitation, and torso exercise: movements regularly made per second; a precise calculation of exercise time was made.
4. On ice: the number of laps and the prescribed speeds were noted for each training session on the ice. So the calculation was made by compiling these data, while distinguishing laps time made by men and women for this type of activity, since the men have faster paces than women.
5. Yoga: for each yoga session, Polar Team[2] was worn by the 15 athletes, allowing collection of time data for each session.

Injuries and training activities attendance

In order to compile the attendance and participation of athletes, a table was made for each day of training, tracking whether the athlete participated in training activities and whether he/she completed some or all of the planned actions. If an absence or non-completion was observed, a note was made explaining the reason for it.

Results

Postural tests

The analysis of the pre-postural and post-postural tests allowed for the identification of significant improvements, with the non-parametric Wilcoxon test, for the following measurements: back bend sky angle (−11.53±16.19, P=0.01), for the two angles of the shoulder alignment of the right shoulder stretch (sky, left shoulder: 12.07±13.34, P=0.005; floor, right shoulder: 8.07±12.48, P=0.01), for the floor angle of the right shoulder and for the difference of angles of the hip alignment in the left shoulder stretch (floor, right shoulder: 7.53±14.45, P=0.005; hips alignment: −11.00±12.24, P=0.005), as for all the measurements of angles of the right side of the runner's pose (supporting leg knee-thigh: 4.07±8.28, P=0.05; supporting leg knee-ankle: 5.40±9.02, P=0.05; balance leg ankle: 12.00±16.35, P=0.01), as well as on the left side of the runner's pose (supporting leg knee-thigh: 6.60±6.64, P=0.005; supporting leg knee-ankle: 7.60±7.88, P=0.005; balance leg ankle: 14.53±13.54, P=0.005). Table 4 presents all of these results.

Motor time-on-task

Table 5 shows, per category of training stimulation, the motor time-on-task received by the athletes during the 8 weeks. We can see that the yoga intervention took a total of 30% of the total time-on-task. Through the 8 weeks, coaches did not notice any change in performance in any of the other activities whatsoever: the compilation of the results for laps on the ice, cycling, and running has shown that athletes managed to accomplish the expected training times despite this major change in their training program. We can then reach the conclusion that adding yoga as a postural training stimulation reached the objectives as it did not interfere with the other training activities and added a significant amount of time spent training.

Furthermore, a quick analysis of the data gathered by Polar Team[2] has shown that the yoga activities stimulated the athletes' cardiovascular system consistently over 80% of their maximum heart rate, and even recorded peaks of 91%.

Table 4 Angles results for the postural tests

Test	Angles (°)	Average difference	Standard deviation	n	Wilcoxon *P*-value
Back bend	Floor angle	1.87	8.07	14	NS: $P>0.05$
	Sky angle	−11.53	16.19	14	$P=0.01$
Right shoulder stretch	Sky: left shoulder	12.07	13.34	14	$P=0.005$
	Floor: right shoulder	8.07	12.48	14	$P=0.01$
	Hips	−2.73	12.56	15	NS: $P>0.05$
Left shoulder stretch	Sky: left shoulder	2.07	16.98	15	NS: $P>0.05$
	Floor: right shoulder	7.53	14.45	15	$P=0.05$
	Hips	−11.00	12.24	15	$P=0.005$
Right leg runner's pose	Supporting leg knee	4.07	8.28	14	$P=0.05$
	Supporting leg ankle–thigh	5.40	9.02	14	$P=0.05$
	Balance leg knee–ankle	12.00	16.35	14	$P=0.01$
Left leg runner's pose	Supporting leg knee–thigh	6.60	6.64	14	$P=0.005$
	Supporting leg knee–ankle	7.60	7.88	15	$P=0.005$
	Balance leg ankle	14.53	13.54	14	$P=0.005$

Abbreviations: NS, not significant; n, number of measures valuable for the Wilcoxon test.

Table 5 Distribution of the motor time-on-task for all training stimulations

Category	Total time-on-task in minutes	Motor time-on-task percentage for the activity	Number of activities by category over the 8 weeks
Yoga	986 min	30%	36
Weightlifting session	500 min	15%	16
Cycling and running	Cycling =560 min Running =174 min 30 sec Agility and speed =30 min Total =764 min 30 sec	24%	14
Stabilization, imitation, and abs workout	Stabilization =60 min Abs workout =91 min Imitation =160 min Total =311 min	10%	22
Ice	Total Men =647 min 21 sec Women =686 min 19 sec	21%	62

Abbreviations: min, minutes; sec, seconds; abs, abdominal.

Injuries and training activities attendance

The attendance and activity completion timetables analysis shows us that absences and missed actions always share the same causes: 1) planned absences for external activities (academic tests, attending meetings related to professional activities, exceptional family-related activities); 2) falls during ice activities; and 3) infectious diseases (flu, intestinal ailments).

No athlete missed any training due to trauma or discomfort linked to one of the training activities.

Discussion

In light of these results, we can conclude that the goals set by the coaches for these sessions were met; the postural functionalities were improved and diversified; motor time-on-task was significantly increased due to the yoga sessions and apart from injuries caused by fall, the athletes managed to accomplish all of the planned training activities in accordance with the expected performances.

On the ice, coaches could notice a change in the athlete's perception of their body schematic related to their skating technique. In fact, after the yoga sessions, head coaches felt that the athletes were more capable of dissociating their torso from their hips and thus increased the efficiency of their skating stride. As for the left opening, two outlier observations (Figure 5) were made that changed the statistical significance of the test, and after analyzing the two subjects, we can see that the shoulder variation angle is negative but that the global execution of instructions has improved, particularly concerning hip position, which is a crucial goal of the sessions.

Furthermore, the pre-test could have been globally biased because of an intuitive technical specificity: in the skating technique, the athletes are used to pushing their hips toward the left while keeping their shoulders parallel to the ground. During the pre-test, in order to open their shoulders as much as possible and meet test requirements, the athletes could have reproduced this strategy.

It would also have been relevant to look at the results as a multiple single case study. Considering the results globally has a tendency to make us lose sight of certain obvious improvements. For some of the athletes, the coaches observed an important transfer to their skating technique, but also in the perception of their body schematic; the technical feedback was better assimilated after the sessions. When considering the analysis of the effort perception in long yoga sessions, one factor stands out: despite the increasingly difficult level of the session, on average the athletes kept the same perceived effort as in the very first session, which shows an adaptation to the stimulation.

Conclusion

Even with a annual training program linked to the global culture of this Olympic sport, it must be said that postural skills were not very present in the organization of training before the introduction of yoga adapted to short track speed skating.

In addition to being linked to the specific skills of the sport, the yoga sessions managed to reach the goals set by the coaches in this high volume out-of-season training period.

This intervention allowed the athletes to create a new functional range, which is usually rare in high level spheres, these individuals often honing the skills specific to their sport. This new functionality was developed without interfering with the other training activities.

Inserting these types of sessions in the annual training program opens a new and promising avenue in many regards:

the prevention of injuries, the effect of developing new motor skills and their transfer, the effect of developing new postural skills and the effect on the strength of segments, and the effect of the variation of heart rate during the postural intervention on different energy circuits.[16,38–40]

Furthermore, yoga is also recognized for its positive effects on psychological dispositions, which constitutes an important field of expertise in research concerning high performance sport.

In compliance with strict methodological guidelines, as the context of the intervention, the choice of positions, the description of protocols, and the educational strategy, more research would clear up this field of activity and enable coaches to begin to develop postural skills sooner in the long-term development of athletes.

Disclosure

The authors report no conflicts of interest in this work.

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