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Managing RISK when treating the injured runner with running retraining, load management and exercise therapy

Running provides an inexpensive form of moderate-vigorous physical activity in order to improve cardiac (Petrovic-Oggiano et al., 2010), metabolic (Williams, 2014) and mental (Ghorbani et al., 2014) health. However, running also increases the risk of musculoskeletal pathology, with prevalence of injury suggested to range from 18% to 92% (Wen, 2007; van Gent et al., 2007). Persistence of running related pain may be driven by both physical and non-physical (e.g. psychosocial profile) factors, providing a range of considerations when developing an optimal management plan.

Multiple biomechanically focussed interventions can be provided by physical therapists when treating an injured runner. Commonly advocated treatments include exercise therapy (Lauersen, Bertelsen, & Andersen, 2014; Yeung, Yeung, & Gillespie, 2011), foot orthoses (Collins et al., 2007; Hume et al., 2008; Yeung et al., 2011), footwear modification (Knapik et al., 2014; Yeung et al., 2011) and taping techniques (Barton et al., 2014; Yeung et al., 2011). Despite the proposed benefits of, and extensive research related to each approach, chronicity of running injuries remains highly prevalent (Rauh et al., 2000), and a great source of frustration for clinicians and patients managing running injuries.

1. Emergence of running retraining as a biomechanical intervention for the injured runner

More recently, running retraining has received increasing attention in the literature and clinical practice (Barton et al., 2016). Running retraining can be defined as "the implementation of any cue or strategy to alter an individual's running technique" (Barton et al., 2016; Davis, 2005), with the majority of the literature dominated by studies evaluating the biomechanical effects of increasing step rate (cadence), and transitioning from a rearfoot strike to a non-rearfoot strike (Barton et al., 2016). Other retraining strategies include cues to run softer, widen stance, change proximal mechanics, and neuromotor cues to engage muscles (e.g. "squeeze your bottom") (Barton et al., 2016).

Clinical trials evaluating running retraining are scarce to date. Early research in this area produced limited evidence from small case series supporting consideration of running retraining in clinical practice (Barton et al., 2016). These findings indicated that transitioning to a non-rearfoot strike in combination with increasing step rate or altering proximal mechanics over a six week period may benefit runners with anterior exertional lower leg pain (Barton et al., 2016; Breen et al., 2015; Diebal et al., 2012). Additionally, visual and verbal feedback to reduce peak hip adduction over a two week period may benefit females with patellofemoral pain (PFP) (Barton et al., 2016; Noehren, Scholz, & Davis, 2011; Willy, Scholz, & Davis, 2012).

Two randomised controlled trials (RCTs) evaluating running retraining in runners with PFP have recently emerged, and these reported conflicting findings in regard to the potential value of running retraining. Roper et al. (2016) reported greater reduction in running related pain following two weeks (8 sessions) of retraining to transition from a rearfoot to non-rearfoot strike when compared to a control group who did not receive any retraining intervention. However, Esculier et al. (2017) did not report the same benefits in reducing running related pain following their 8 week (5 sessions) retraining intervention focused on increasing step rate by 7.5% compared to an education control.

One possible explanation for the conflicting running retraining RCT findings in runners with PFP (Esculier et al., 2017; Roper et al., 2016) may be the more comprehensive load management education provided in the Esculier et al. (2017) study. Additionally, the two studies also implemented clearly different retraining strategies, which possibly contributed to the conflicting findings. Specifically, transitioning to a non-rearfoot strike will produce different biomechanical outcomes compared with increasing step rate, especially in runners who already possess a high step rate (Barton et al., 2016). Esculier et al's. (2017) study has also been criticised for not adhering to motor learning principles, as they provided only instruction during treatment sessions, and did not facilitate any structured retraining feedback schedule (Davis, 2017). Previous studies supporting running retraining, including Roper et al. (Roper et al., 2016), have all used a structured faded feedback approach, which is believed to be important to facilitate motor learning (Davis, 2017). Two of these studies, Willy et al. (2012) and Noehren et al. (2011) also targeted their retraining interventions to reduce peak hip adduction in a group of female runners screened for excessive hip adduction during running. This highlights that running retraining may also be most effective when targeted to individuals needs of the injured runner.

2. The importance of clearly defining running retraining interventions and understanding their potential variable effects

Pharmacotherapies such as analgesia (e.g. paracetamol and non-steroidal-*anti*-inflammatories) are not all put into the same category when designing, reporting, and synthesising clinical trials, because different drugs will have different effects. Gait retraining is no different, and like pharmacotherapies, different prescriptions (e.g. step rate or changing strike pattern) will possess different risks and may lead to different clinical outcomes. Therefore, tailoring retraining strategies to specific conditions and individual running

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biomechanics has the potential to optimise outcomes and improve safety of use in clinical practice. This is a notion supported by expert opinion (Barton et al., 2016), but at this point there is no clear evidence from clinical trials to provide guidance to clinical practice on how to do this.

There are many running retraining and other treatment options for the clinician to consider when managing running injuries. Each has varying, and sometimes absent or conflicting evidence to support their use, making clinical reasoning and treatment decisions more difficult. Ideally, treatment choices should be based on a shared decision making process, where the patient is guided by the clinician to weigh up the relative risks, benefits and time commitment of each treatment option available (Barton & Crossley, 2016). Therefore, it is vitally important that all running retraining interventions are not lumped together during clinical reasoning. But, is there a framework which can assist the clinical reasoning process when determining the potential value of various running retraining and other biomechanical interventions?

3. Considering the RISK of biomechanical interventions

To guide clinical reasoning and discussion with the injured runner in relation to biomechanically focussed interventions, a simple categorisation approach can be adopted and used to optimise treatment choices – ***RISK (Reduce overall load, Improve capacity to attenuate loads, Shift loads, Keep adapting to the runners goals and capacity).***

The remainder of the Editorial will discuss each component of the RISK framework, with specific reference to running retraining, along with other commonly employed interventions – load management and exercise. Overarching principles of the RISK framework and examples are provided in Table 1. A number of other physical and non-physical interventions may be beneficial (taping, footwear, foot orthoses, etc.), and can also be considered during the clinical reasoning process using the RISK framework. However, it is beyond the scope of this piece to discuss all options to treat the injured runner.

4. R – Reduce overall load

4.1. Running retraining

One running retraining intervention consistently proposed by experts when treating the injured runner is to implement strategies to reduce overstride (i.e. reduce the horizontal distance between foot strike and centre of mass (COM)) (Barton et al., 2016). Supporting this notion, biomechanical research indicates that there is an association of the distance between foot strike and COM and magnitude of knee joint loading (Wille et al., 2014). One intervention capable of achieving a reduction in overstride is to increase step rate (Heiderscheit et al., 2011). As such, implementing strategies to increase step rate such as the use of a metronome or real time feedback from a watch (Willy et al., 2015), may provide a safe biomechanical intervention to reduce overall load in almost all injured runners. However, considering the lack of apparent efficacy when tested in a heterogeneous group of runners with PFP (Esculier et al., 2017), further research is needed to determine if targeting retraining to increase step rate (e.g. if step rate is less than 170) may be more appropriate. Additionally, consideration to increasing step rate in other common running injuries has also been encouraged by experts (Barton et al., 2016), and recent research indicates that lower step rates may be associated with greater risk of shin pain but not anterior knee pain in a running population (Luedke et al., 2016). This highlights a need for further research on the efficacy of increasing step rate in other populations.

4.2. Modify running training

There is a long held belief that running injuries primarily result from increasing training loads too fast – i.e. 'too much, too soon' (Barton et al., 2016). However, evidence to support this notion is limited (Nielsen et al., 2013; Rauh, 2014). Regardless, results from the recent RCT by Esculier et al. (2017) in PFP highlights that education related to load management may be an important intervention when treating the injured runner with PFP. Specific education included reducing running distances and speed, and avoiding running downhill and stairs. Similar approaches may also be implemented for other conditions, particularly related to running distances and speeds. Regardless of the safety and potential benefits of temporarily reducing overall loads, further intervention may still be required when treating the injured runner. Importantly, in the study by Esculier et al. (2017), average running related pain remained at more than 2/10 at 20 weeks following load management education. Thus, an important element in recovery from persistent running-related injuries, such as PFP, may still be missing.

Table 1
Overarching principles of the RISK framework and examples of where biomechanical interventions reported in the literature might fit.

	R Reduce overall loads	I Improve capacity to attenuate loads	S Shift loads	K Keep adapting to the goals and capacity of the runner
Overarching principles	Reducing load is the safest and easiest to implement treatment when managing the injured runner, and thus should be the primary focus in the early stages of a management plan.	Well implemented strategies to improve capacity to attenuate loads such as exercise therapy and gradual increases to running loads are safe to implement. However, they take time investment from the runner and require careful therapist's guidance.	Shifting loads away from injured or symptomatic tissues may be desirable when treating the injured runner and this can often be implemented immediately. However, caution not to cause other injuries during this process is essential.	Although the R, I, and S components of the RISK framework will help guide the clinical reasoning process when treating the injured runner, it is important to consider each individual patient, including their goals and underlying capacity for change.
Examples of options	- Reduce running loads (distance, speed - Increase step rate[a]	- Exercise therapy, and strength and conditioning - Gradual increases to running loads	- Transition from rearfoot to non-rearfoot strike; ↓ loads on the knee and ↑ loads on the foot and ankle - Neuromotor cues to engage gluteals; ↑ loads on the gluteals and ↓ loads on other muscles (e.g. quadriceps)	- Implement desired running retraining strategies following the completion of a race or competitive season - Complete a preparatory strength and conditioning program of the foot and ankle musculature to improve the safety of transitioning to a non-rearfoot strike pattern

[a] Increasing step rate will generally reduce overall loads, but a summary of biomechanical evidence indicates an increase in demands on the gluteals, hamstrings and triceps surae during late swing.

5. I – Improve capacity to attenuate loads

5.1. Exercise therapy

Exercise therapy has been widely adopted when treating injured runners, and possesses a growing evidence base (Lauersen et al., 2014; Yeung et al., 2011). It is clear from previous research that exercise targeting muscle strength does not seem to alter running kinematics, in both uninjured and inured runners (Earl & Hoch, 2011; Ferber, Kendall, & Farr, 2011; Neal et al., 2016; Willy & Davis, 2011). Nonetheless, pain reduction has been reported in the short term following hip and knee exercise therapy, and this has been accompanied by both reductions in knee joint loading (Earl & Hoch, 2011), and vertical loading rates (Esculier, Bouyer, & Roy, 2016) in runners with PFP. Together this indicates that the mechanism of exercise therapy may be via improvement in the capacity of the runner to attenuate load. Further support for the potential of exercise therapy to improve the capacity to attenuate load is provided by findings of Esculier et al.'s recent RCT (Esculier et al., 2017). Although not statistically significant, reductions in running related pain was greater in the group receiving exercise therapy combined with education compared to education alone (1.2/10; 95% CI = −2.4 to 0.1). This outcome may be clinically meaningful, especially considering the concurrent increases in running volumes following exercise therapy. Specifically the group receiving eight weeks of exercise therapy targeting the hip and knee combined with load management education were able to increase their weekly running volumes by 26% at eight weeks. This was significantly more than the group receiving load management education alone who increased volumes by 7% at the same point.

Theoretically, further improvements in capacity to attenuate load in the injured runner may be achieved via longer and more progressive exercise therapy programs than those reported in the literature. For example, the exercise therapy program used by Esculier et al. (2017) was guided by a physiotherapist for just 8 weeks, and by 20 weeks, there were no apparent added benefits of this program when combined with load management education. However, it is unclear if adherence was maintained beyond eight weeks, and it would be difficult for the patient to continue to appropriately progress exercises to ensure a sustained effect on muscular strength, power and hypertrophy by following accepted strength and conditioning principles (Garber et al., 2011).

To truly improve a runner's capacity to attenuate loads, they should be encouraged to continue and progress exercise therapy and resistance training programs well beyond the commonly researched 8–12 week period. It is important to note following the commencement of resistance training, signs of muscle hypertrophy are not likely for at least six weeks (Garber et al., 2011), and tendon cross section area will not begin to increase for at least 12 weeks (Wiesinger et al., 2015). Therefore, optimisting and sustaining exercise therapy benefits may take a number of months in the injured runner due to associated muscle atrophy (Giles et al., 2013), along with likely muscular strength (Rathleff et al., 2014) and power (Nunes, Barton, & Serrão, 2017) deficits. Additionally, there may be a need to progress resistance training loads more slowly in order to avoid pain flares in the injured runner.

5.2. Gradual increases to running loads

When tissues are provided with optimal loading, they have a remarkable ability to adapt. Although, an understanding of how to determine optimal loading for each injured runner does not currently exist, there is evidence to suggest loading of tendon, muscle, cartilage and bone can optimise tissue healing and remodelling (Khan & Scott, 2009). For more detailed explanations, the reader is encouraged to consult the paper by Khan and Scott (2009). The important point is that appropriate (i.e. not exceeding the tissues capacity) and frequent loading stimulus (e.g. running participation), may improve an individual's capacity to attenuate loads associated with running through tissue remodelling (adaptive homeostasis) (Khan & Scott, 2009). In regard to treating the injured runner, this may involve either exercise therapy as previously discussed, or simply sensible increases to running loads including volume and speed (e.g. increasing by 10% per week). Gradual increases to running loads will be particularly important for goal orientated runners where running loads have been reduced in the early stages of their treatment. Indeed, peak tissue loads observed during running can easily be simulated via heavy, slow weight training. Yet, the high rate of applied loading and the cumulative loads inherent to running can really only be achieved via the task of running (Willy & Meira, 2016).

6. S – Shift loads

6.1. Running retraining

There is emerging evidence that running retraining strategies to shift load may be effective for treating the injured runner. Specifically, transitioning from a rearfoot to a non-rearfoot strike has been reported to effectively reduce running related anterior exertional lower leg pain (Barton et al., 2016; Breen et al., 2015; Diebal et al., 2012) and PFP (Roper et al., 2016). However, if the individual does not possess adequate capacity of the intrinsic foot and calf musculature to make this change, caution is needed and recommended, so that additional injury does not result (Barton et al., 2016). In fact calf, foot and ankle soreness is common during transition (Barton et al., 2016; Breen et al., 2015; Diebal et al., 2012; Esculier et al., 2017). Therefore, preparatory strength and conditioning programs (intrinsic and calf strengthening, jumping, hopping) are recommended prior to initiating, or during transition, and retraining should be gradually introduced (Barton et al., 2016). In some cases, implementation of a planned running retraining intervention may be delayed by a number of weeks or months whilst capacity is developed. The same caution and preparatory approach is recommended if using running retraining to shift load more proximally (e.g. cues to increase gluteal activation or improve pelvic and trunk control).

In addition to preparatory interventions like strength and conditioning, it is also vitally important to gradually implement any running retraining interventions which might shift loads to other tissues. In fact, all running retraining interventions will increase loads on some tissues. This is even true for increasing step rate, which can effectively reduce overall loads (Wille et al., 2014). Specifically, greater step rate is associated with higher muscle activity of the gluteals, hamstrings and triceps surae during late swing (Barton et al., 2016). Readers are encouraged to consult Barton et al. (2016) for a more detailed summary of the biomechanical outcomes of various running retraining interventions, and stay abreast of emerging research in this area in order to understand potential load shifts.

7. K – Keep adapting to the injured runners goals and capacity

7.1. Adapt to goals

Reduction in running loads may not be desirable for the injured runner in the short term if they have upcoming races. Specifically, associated loads as a result of race and training participation may impair the ability of a runner to incorporate potentially therapeutic interventions. Both exercise therapy and running retraining strategies can add more load to tissues while being incorporated into a training plan, and thus may require reductions in short term running loads. Running retraining strategies are also likely to be associated with impaired running economy in the short term (Townshend, Franettovich Smith, & Creaby, 2017), which would impact on performance. In these instances, shared decision making is encouraged, and the decision to implement biomechanical interventions like exercise therapy and running retraining may be delayed until a quieter period in the race calendar.

7.2. Adapt to capacity

Past injuries may also limit an injured runner's capacity to incorporate an optimal running retraining strategy as part of their treatment. For example, if a runner presents with significant PFP, but also has a history of chronic Achilles tendinopathy, transitioning to a non-rearfoot strike to shift load away from the knee may need to be avoided or completed much more slowly. The key point is that there is unlikely to be a recipe which will lead to optimal running retraining, or other biomechanical interventions for all injured runners. Each plan should be adapted to an individual's underlying capacity for change, and the relative benefits and safety of each option considered in the context of the remainder of the RISK framework.

8. Conclusion

This editorial has been written to provide the clinician with a simple framework to help them to determine the potential value of running retraining and other biomechanical treatments for the injured runner – **RISK** (see Table 1 for a summary of principles and examples).

Reducing overall loads by decreasing running loads (speeds, volume) and/or running retraining strategies to reduce overstride where appropriate should be prioritised when initially treating the injured runner. Considering the large body of supportive evidence for exercise therapy, ***improving capacity to attenuate loads*** should also be implemented where possible, and may allow the injured runner to increase running loads sooner. Sensible gradual increases to running loads will also facilitate tissue remodelling and improved capacity over time. ***Shifting loads*** away from injured or symptomatic tissues through various running retraining interventions can also be considered and may be desirable in the longer term. However, due to associated increases in loads on other tissues, care must be taken and the capacity of these tissues taking additional loads adapted to ensure they are capable of attenuating them. It is also important that treatment plans ***keep adapting to the injured runners goals and capacity,*** ensuring shared decision making and ongoing optimisation of treatment.

The remainder of this special edition will maintain a strong clinical focus on treating the injured runner. First, a clinical commentary from Willy will provide the reader with an understanding of innovations and pitfalls of using wearable devices to measure and monitor running loads, which may prove particularly useful to assist in using strategies to reduce overall loads. Additionally, papers related to the validity and reliability of simple video methods which can assist research and clinical practice in determining the potential value and effects of running retraining interventions will follow. Specifically, this includes assessment of frontal plane mechanics of the pelvis, hip and knee; as well as foot strike pattern and step rate. Finally, results from new research evaluating the biomechanical and clinical outcomes of altering footwear and running retraining strategies are provided, and the reader is encouraged to consider the RISK framework when interpreting the results from these studies and how they might be used in with their patients.

Conflict of interest

Dr Barton receives some income and research funding through teaching courses related to treating injured runners with running retraining, exercise and education.

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