Correcting recent misunderstandings of the StARRT framework for return-to-play decision making

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Please cite as: Shrier I., (2022). Correcting recent misunderstandings of the StARRT framework for return-to-play decision making e. *SportRχiv*.

ABSTRACT

The Strategic Assessment of Risk and Risk Tolerance (StARRT) framework for return to play decision making follows a biopsychosocial causal philosophy for injury. A recent editorial in the British Journal of Sports Medicine suggested that the framework required modifications to incorporate "load". However, the original framework already included load and the suggested modifications were based on a misunderstanding of the framework. Further, the power of the StARRT framework is in its simplicity which can be followed by any stakeholder (e.g. clinician, coach, participant). The purpose of this article is to review and clarify how the StARRT framework is supposed to be applied, discuss that it already includes load, and demonstrate how it can be operationalized to specific contexts and implemented when designing load management strategies (training prescription) during rehabilitation.

All authors have read and approved this version of the manuscript. This article was last modified on July 16, 2022.

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INTRODUCTION

A recent editorial in the British Journal of Sports Medicine (BJSM)[1] suggested some modifications were required to the Strategic Assessment of Risk and Risk Tolerance (StARRT) framework for return to play (RTP) decision making, first published in 2015.[2] The editorial title begins "Where is the load?..." and the authors argue that StARRT needs changes to incorporate "sports-specific training capacity". From personal communication with the authors and editor, the editorial went through three peer review stages, and was then considered acceptable for publication by the senior BJSM editors. The editorial was well-intentioned and raises some awareness about issues to consider when designing load management (training prescription) strategies during rehabilitation.

The StARRT framework is a general framework. The strength of the framework is its simplicity; "…it is a process that can be followed by any decision-maker, whether this is a clinician, an athlete, a parent, a judge or a shared decision-making process"[2] for any RTP decision, in any population or context. As such, it uses general constructs. Practitioners must adapt these general constructs to their specific contexts. These adaptations will depend on the available information and resources. This will likely entail changing some of the labels, definitions, and so on. That said, the editorial's recommended changes suggest a misunderstanding on how to interpret and use the StARRT framework even for operationalization. Aside from the more serious challenges described below, the recommended changes create redundancy, which may confuse those making RTP decisions. Given these concepts were missed by the authors, and by both peer reviewers and senior BJSM editors, the purpose of this article is to clarify how the StARRT framework is supposed to be applied, discuss that it already includes load (through factors that determine expected load such as sport, player position and competitive level), and demonstrate how to operationalize it so it can be used to design load management strategies during rehabilitation.

Normally, comments on published papers would be submitted as a letter to the Editor to the journal (i.e. BJSM). Unfortunately, BJSM editorial and publishing philosophy does not allow letters to the editor critiquing its published articles. Therefore, as with a previous paper in BJSM that contained serious errors [3], publishing through a preprint server without peer review appears the only method to reach the large audience who use the StARRT framework.

Defining terms and objectives

Two of the most important limitations of the editorial are that it (1) fails to appropriately define terms, and (2) conflates factors involved in making a RTP decision with objectives of the RTP decision. First, the title refers to "load," but the text does not define it. Load, in its generic sense, usually refers to the amount of physical stress referring to forces, pressures, and torque. Later, the editorial uses "chronic load". Chronic load usually refers to some type of summary of past activity (e.g. quantitative and/or qualitative). In the editorial, the authors sometimes use chronic load to refer to pre-injury activity, and sometimes use chronic load to refer to recent activity during rehabilitation (personal communication). Second, "sports-specific training capacity" is initially defined as "an athlete's overall ability to cope with diverse demands of training and competition imposed by their ecosystem and perform at the required level." The ability to *cope with demands of training* seems to refer to participating without developing an injury or illness, which represents a desired outcome of a RTP decision. However, a construct cannot represent both information that helps determine the probability (or more generally, expectation) of an outcome and the outcome itself. Later, the editorial says sports-specific training capacity "comprises the important contribution of chronic load to tissue stress and its subcomponents…". This implies a different definition from the original, and this definition is similar to the concept of chronic load. Finally, Table 1 of the editorial introduces some thoughts on how one might incorporate chronic load within the StARRT framework to design load management strategies during rehabilitation, which has the title "Key considerations when developing chronic load using the example of an elite football player's return-to-sport".

Based on the above, the reader would assume that the purpose of the recent editorial was to recommend changes to incorporate chronic load and its relation to load management strategies during rehabilitation into the StARRT framework because they were previously missing. In fact, as explained below, both past load and expected future load are included in the original StARRT framework although different terminology is used.

Review of the StARRT framework: the advantages of simplicity

The 3-step StARRT framework (Figure 1) is based on concepts from the Bayesian Decision Theoretic (to make decisions under uncertainty), and follows a biopsychosocial causal philosophy for injury. An earlier RTP framework was based on a sociological framework[4] which begins by considering the source of the information, e.g. a medical professional, a coach or another individual. The biopsychosocial causal framework was created because audiences at conferences found the sociological framework confusing to implement and use.

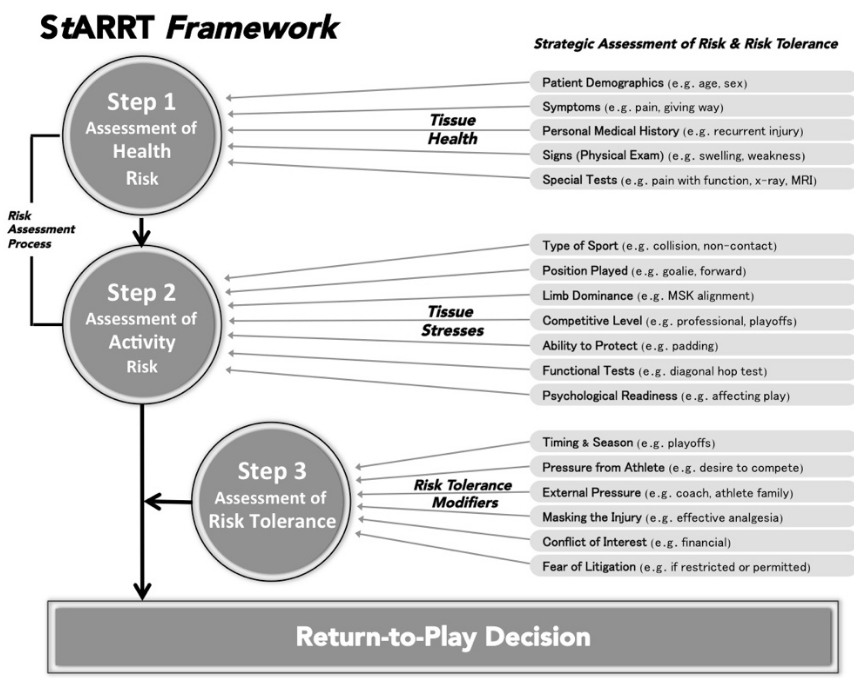

Figure 1. The Strategic Assessment of Risk and Risk Tolerance (StARRT) framework for return-to-play (RTP) decisions. This framework illustrates that patients should be allowed to RTP when the risk assessment (Steps 1 and 2) is below what the clinician / patient are willing to tolerate (called risk tolerance threshold, Step 3), and not allowed to RTP if the risk assessment is above the risk tolerance threshold. The StARRT framework groups factors according to their causal relationships with the two components of risk assessment ("tissue capacity to resist injury" referred to as Tissue Health in the figure, and stresses applied to tissue) and risk tolerance. In some cases, apparently a single factor can have more than one causal connection and would be repeated if it influences more than one step of the framework. For example, play-offs will increase the competitive level of play and therefore increase Tissue Stresses and increase risk (Step 2). However, it is also expected to affect a patient's desire to compete (i.e. mood, risk of depression) and could affect financial benefit as well. These causal effects would lead to increased risk tolerance (Step 3). In this framework, each outcome is evaluated for RTP, and the overall decision is based on the most restricted activity across all outcomes (see text and table 1 for details). MSK, musculoskeletal. (adapted from [2]).

In the StARRT framework, we assess the biological risk of activity through Steps 1 and 2. In Step 1, we determine how much physical stress the <u>injured tissue</u> can withstand. The original framework used the words "tissue health" as the construct label (Figure 1). This is vague and the words "tissue capacity to resist injury" better represent the construct. In this paper, I use "tissue capacity" for brevity. For the outcome injury, this is mostly determined by tissue strength. The information is gathered through various sources such as symptoms, functional testing, and laboratory tests. In Step 2, our objective is to estimate (anticipate) how much stress the upcoming physical activity session(s) will create on the <u>injured tissue</u>. The closer the expected stress (Step 2) is to the estimated tissue capacity (Step 1), the higher the risk of injury. Once we estimate the risk of injury during the upcoming activity, we apply value judgements in Step 3 to determine risk tolerance. Risk tolerance reflects a value judgment whether the benefits of that activity (e.g. enjoyment, financial reward) outweigh the risks. Finally, the same principles apply to injury prevention except we are interested in injuries to any tissue instead of focusing mostly on the previously injured tissue. The framework can also be applied to the outcome illness where "injury" is used in the more general sense of tissue damage, which may be due to infection or disease (although some of the factors for Step 1 and Step 2 would be different). That is the entire framework. The concept is simple, and it follows guidelines for appropriate medical care and shared decision making.

Misinterpretations of the StARRT framework

The stated motivation of the recent editorial in BJSM was that the StARRT framework did not include adequate detail on "quantitative and qualitative aspects of load. The authors recommend adding a bubble to Step 2 that would include these concepts. Within the second section of their editorial, the authors refer to concepts of "progressive development of physical qualities" and "re-establish chronic load".

Although the StARRT framework is simple and accessible to a wide audience, explaining why the recommended changes are not just redundant but inappropriate requires some technical discussions. For example, one challenge with the editorial is that the authors appear to move back and forth between pre-injury and post-injury concepts, and it is not always clear when they are referring to which. In this article, I either explicitly define what I think the authors likely meant, or try to review the implications of different possible interpretations of what was written.

In the section that specifically recommends changes, the editorial suggests that "sports-specific training capacity "comprises the important contribution of chronic load to tissue stress and its subcomponents". The subcomponents are sub-categorized into three domains: quantitative, qualitative, representative design. Here, I assume the authors are now referring to sports-specific training capacity as a risk factor for injury (determined mostly by chronic load) rather than their previous definition, which represented an outcome. Further, the editorial also refers to "contribution of chronic load to tissue stress". Here, I assume they mean chronic load as a main factor to be considered when designing load management strategies during rehabilitation. These additions represent the main focus of their editorial. The imprecise wording of the bubble and text is likely to cause important confusion among readers and clinicians.

There are several possible meanings for sports-specific training capacity and/or chronic load, each leading to potentially different recommendations for the framework. They may refer to:

1. What was (the past): *Training capacity / chronic load* may be referring to the tissue capacity of the injured tissue *prior to the injury*: This does not fit in Step 1 or Step 2 of StARRT. In practice, clinicians often use past tissue capacity (often estimated by pre-season physical exam, functional testing, etc.) as a benchmark for what current tissue capacity *should be* before RTP. But this is different from the relevant factor in Step 1, which requires a measure of *current tissue capacity*. Therefore, it does not belong in Step 1. Also, it does not directly affect the expected activity to be done at the time the participant returns to activity. Therefore, it does not belong in Step 2.
2. What is (the present): *Training capacity / chronic load* may be referring to the tissue capacity of the injured tissue *at the time of the RTP decision*: Here, chronic load would refer to the activity of the last few days as a measure of stresses the tissue can withstand without being injured. In this case, the terms are directly referring to the tissue capacity at the time of RTP. By definition, this is Step 1, not Step 2.
3. What will be (the future): *Training capacity / chronic load* may be referring to the EXPECTED stress during activity when the participant returns to sport: Here, chronic load in the days to weeks before the injury acts as a proxy for expected (anticipated) activity in the future. There is more risk of further damage or reinjury if a person with a lower limb injury is going to run 10km compared to 5 km. With this definition, the recent editorial would be correct in placing the bubble and text under Step 2. However, this definition has serious limitations. Previous activity pre-injury is only a proxy for expected activity at RTP. Indeed, the recent editorial discusses the need for progressive return to activity. If the load management strategy is to progressively increase activity towards pre-injury levels of activity, then by definition, the amount of activity that is

expected to occur at the time of RTP decision during this re-integration phase is less than the "chronic load stress" or previous "sport specific training capacity". Clinicians making RTP decisions should be aware of the actual expected stresses, and we should not be recommending that they use poor proxies in their decision-making process when more accurate information is available.

The authors made some minor changes to several bubbles to reflect their own preferences or context (e.g. patient vs. athlete). Most of these are inconsequential. However, they recommended renaming one of the bubbles in Step 2 from "Functional Tests" to "Strength and Power Diagnostics". The term "Diagnostics" may imply "diagnosis", and a reference to tests on the injured tissue. Although this was not the intention of the authors (personal communication), the editorial did not clearly distinguish between information obtained on injured tissue from information obtained on healthy tissue. Indeed, the authors say "Frequent monitoring of load–response to estimate the impact of imposed stressors on local tissue/ structure(s) adds insights to the holistic risk assessment process…". If the editorial is referring to the capacity of the injured tissue, this bubble would now belong in Step 1, not Step 2. The original StARRT article explicitly defined Functional Tests as tests of *healthy tissue*, not injured tissue. To borrow and adapt terminology from work in the sport sciences,[5] tests of uninjured tissue provide information concerning how much of the external stress (activity) is transmitted to the injured tissue (internal stress). Consider a participant with back pain. If we have a fixed external stress (activity) on the body, the person with poor hamstring (uninjured tissue) strength / flexibility may experience a greater stress on the back (injured tissue); it is this stress on the back that is responsible for the risk of exacerbation or re-injury. The specific text in the original StARRT framework read: "However, the postinjury decrease in endurance and strength, and range of motion of tissues that have not been injured are clearly not related to the health status of the damaged tissue we are trying to evaluate, nor are they related to sport. Within the biological causal framework of StARRT, decreased endurance means an increase in fatigue, which means an increase in stress transmitted to other structures. Similarly, decreased proprioception will increase the stresses that occur across many structures. Other examples include inflexible hamstrings increasing stress on the low back, and scapular dyskinesis increasing the stress on the rotator cuff."

There is one additional point in the editorial unrelated to StARRT that I feel requires elaboration if one is interested in developing load management strategies. The figure legend includes the phrase "… and magnitude/direction of % interlimb asymmetry." Some continuing education courses claim asymmetry of strength, flexibility, movement is a fundamental problem and is associated with an increased risk of injury even though the evidence appears inconclusive.[6] First, most of us are asymmetrical, and some sports actually require asymmetry (e.g. baseball pitcher, American Football field goal kickers). More importantly, in the context of RTP decision-making, if one truly believed symmetry were a causal factor for injury, then we should achieve similar results by weakening / stiffening the healthy limb compared to strengthening / mobilizing the injured limb. I am not aware of any sport medicine clinician that would recommend such treatment. Therefore, asymmetry can be used as a proxy for the strength, flexibility, kinesthesia and proprioception of the muscle prior to injury (or prior to having an increased risk of injury), but is not generally an important causal factor itself.

Designing load management using the StARRT framework

I now return to the recent editorial authors' objectives to operationalize (which is different from modify) the StARRT framework to the specific context of designing load management strategies during the rehabilitation phase. There is always a tension between grouping constructs that are similar, and keeping constructs separate because they are not identical. Each user will have a different threshold for grouping depending on their own philosophy and context about how much should be included in the adapted summary framework, and how much belongs in separate explanatory documents that would be useful given the experience and knowledge of the user and their team.

RTP is specific to a level of activity.[7] Usually, clearance for training is provided well before clearance for non-contact activity, which is provided well before clearance for contact activity. Medical doctors are often given the responsibility / authority for making these activity-specific RTP decisions, whether this be a general work-related injury or a sport-related (work-related or recreational) injury. However, a priori, medical doctors do not have any additional knowledge or expertise to make these decisions.[8 9] Indeed, load management strategies during rehabilitation are usually developed by therapists and coaches, with the lead being partially determined on whether the program is prevention or the phase of rehabilitation. Figure 2 represents a model of athlete care from prevention to re-integration originally conceived by Jay Mellette, Director of Sports Performance and Head Athletic Trainer of the Vegas Golden Knights, National Hockey League and first published in [10].

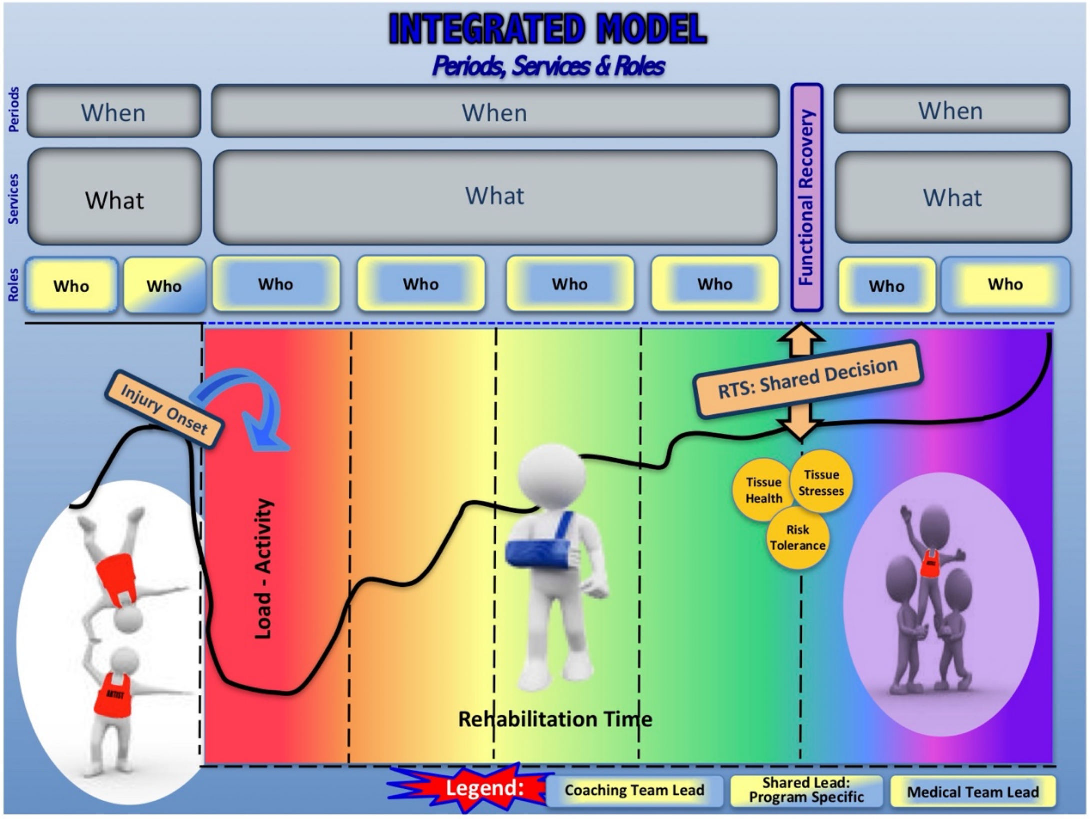

Figure 2. The FAIR (From Activity to Injury to Rehabilitation/ Reintegration) model of athlete care. The relationship between the athlete, coach and the health care team begins with a healthy athlete. During this time, the coaching staff is usually the lead in establishing training and competition workload to improve performance and minimize injury. The health care team provides a supporting role and addresses limitations identified through history and physical examination, or through prevention programs directed at specific requirements of the position within the sport. At the time of injury, the coaching staff and health care team both contribute substantially in establishing appropriate workload and managing expectations. During the initial phase of rehabilitation, the health care team has more influence, and the coaching staff provides the supporting role. As the athlete's injury heals, there is a gradual shift towards the coaching staff taking more responsibility and authority. In the post-injury phase, there is still some focus on prevention of reinjury, and the training returns towards the goal of optimizing performance and long-term health. (reproduced from [10]).

When a load management strategy for rehabilitation is being developed, it is created with the idea that each load at each stage represents an acceptable risk to the participant (in relation to the potential benefits). In the original StARRT framework, the decision is made on the day that the tissue capacity (Step 1) is assessed. When designing a load management strategy for an injury, the clinician / coach needs to plan activity over days to weeks. Therefore, the clinician / coach must "predict" what the tissue capacity will be for each day in the future, and then match the prescribed activity (Step 2) for that tissue capacity. For example, a clinician might predict that an injured hamstring will be able to absorb the stress of jogging after 2 weeks, and able to absorb the stress of sprinting after 4 weeks. The progressive load program is created *as if* these tissue capacities were going to occur.

We now have a progressive rehabilitation program based on the StARRT framework, where tissue capacity is based on predictions from information obtained sometime in the past. However, different participants and different injuries will heal at different rates; predicted tissue capacity is unlikely to be accurate in many patients. Therefore, we should try to correct any errors in our "prediction" as soon as possible and adapt our original load management strategy appropriately. To do this, we need to collect more data, which is done through "Frequent monitoring of load–response to estimate the impact of imposed stressors on local tissue/ structure(s)…" as recommended by the authors of the recent editorial.[1]

Considerations when prescribing activity

The authors recommend three considerations when developing a load management strategy that should be allowed for a participant, i.e. the suggested progressive activity plan would receive a Yes for the RTP decision for each day. Their first consideration was "Quantitative aspects" (volume, duration, intensity and density). In the original StARRT article, the text refers to the FITT (frequency, intensity, timing and type) principle, and the bubbles include type of sport, position and competitive level (which represent the determinants of FITT). The recent editorial defined "density" as "successive training days", which is an important component of activity that is not completely captured by frequency. Muscle damage occurs with each exercise session, and we need to allow time for healing to baseline and then a training effect for improvement. If activity sessions are scheduled too close together, further injury will be likely.

The importance of density in load management may be underestimated by participants and it can be modelled in different ways in the StARRT framework depending on one's perspective. Above, I suggested that tissue capacity is predicted / evaluated for each day. In this perspective, all that is important is the tissue capacity on that day and the "tissue capacity trajectory" from the past does not matter, i.e. the potential damage caused by density is already covered by predicting/measuring Step 1 daily. In fact, this perspective follows the Bayesian Decision Theoretic on which the framework is based (called Markov chain property, https://towardsdatascience.com/monte-carlo-markov-chain-mcmc-explained-94e3a6c8de11). Alternatively, one could try to predict how much cumulative activity can be done over the next few days given a level of tissue capacity today (as opposed to the perspective above which only looks at activity to be done today). In this alternative perspective, density would be an important component of Step 2 – the amount of expected stress the damaged tissue will be exposed to. Both methods are valid. Finally, it is not incorrect to add a specific bubble for a specific task, but users of the StARRT framework should ensure that they do not "double count" or overemphasize one feature through inadvertent duplication of information.

The second category listed was “Qualitative Aspects” (awareness and perception of movement). Most of the items listed under this category directly say they are affected by player position in the description provided, and therefore are already included in Step 2 of StARRT. The “neurocognitive challenges” within qualitative aspects also includes stresses related to position (e.g. transitioning from offense to defense, location in the pitch). The third category listed is “Representative design of load application”. All of the items in this category are caused by the type of sport, player position, and competitive level.

Conclusion

The StARRT framework is a general framework to help diverse stakeholders (e.g. clinicians, coaches, participants, parents) organize information obtained by various sources into a coherent summary that helps make RTP decisions transparent. The principles are simple and straightforward: Estimate the risk of injury by comparing the injured tissue’s capacity to resist injury, with the expected level of stress that will be applied to the injured tissue. These steps already include all aspects related to the specific stress imposed by the training load (which depends on sport type), can also be applied to load management during rehabilitation, and are also applicable to prevention strategies for healthy tissue. Adding a new element such as sport specific training capacity is thus redundant and unnecessary. Certainly, each user needs to adapt the labels of the framework (either formally or informally) and increase / decrease the number of bubbles to operationalize the general constructs to their specific context (e.g. sport, competitive level, population, etc) based on established understanding of a biopsychosocial causal model of injury and injury prevention.

Acknowledgements

The author would like to thank Steven D. Stovitz, Jay Mellette, Franco Impellizzeri, Matt Taberner and Johann Windt for their helpful comments on early versions of the manuscript.

Funding information

This work was unfunded.

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