Physiological Screening in Performance Climbing Adolescents

A Literature Review and Analysis

Danny Brown

January 2014

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What is a Literature Review?

Simply put prior to engaging in any form of research it makes sense to see if it has been done before and how recently. It might mean you don't need to do the research at all if someone else has just done it but this is extremely unlikely. There is an awful lot of research going on at any one time but there is so much to know that it is fairly easy to find something new to study.

So literature reviews tend to be about adding some context to your particular specialist area and allowing you focus your study and explain any findings more comprehensively. For example there is a study (which I have not used in the review) on the correlation between pubertal maturity in boys and grip strength (Backous 1990). This would give me some baseline figures for a grip strength/climbing ability study which would allow me to determine whether my cohort of climbing kids were stronger than average.

The most important reason for a literature review (and the specific reason for this one) is to gather information. Whilst I know injury screening is a good thing I need to know what other people are doing and have been doing. Climbing is a niche sport and there is no money to carry out research and Britain is particularly bad at investing in sport so I need to look to football (American), basketball, athletics, netball, handball, tennis and gymnastics to get a sense of what is good practice. And obviously I need to look to the countries that invest in sporting greatness married with good quality research preferably written in English.

Explanatory notes

Literature reviews are normally carried out as part of some research by academics and follow a (fairly) strict protocol. Whilst I know what this is I have chosen to keep this as readable as possible. As you can tell I am using the first and third person and those with a more pedantic bent can see that I am not referencing correctly.
Any omissions, mistakes, inconsistencies, irrelevancies and just plain nonsenses are mine and I make my apologies here.

To clarify my remit of this review I should discuss the definition of climbing. In this context it relates to indoor climbing on an artificial climbing wall. Sport climbing is the ascent of a vertical wall using a rope, attached at short intervals to protect the climber in the event of a fall. Bouldering is the completion of short climbs or 'problems' generally less than 4m in height – often much shorter. Small studies have shown that the injury prevalence in sports climbing is higher than that in bouldering despite bouldering allowing for wider participation and the ability to attempt much harder (i.e. more likely to produce injury) problems.
Factors that contribute to this would include fatigue, stamina and not insignificantly, stress and the desire to succeed (also stress).

This review is also specifically dealing with high performance climbers – the top 1% if you like. As well as this children often have disparities between their body morphology and their ability to climb and benefit hugely from generally being lighter, less prone to fatigue and less encumbered by lifestyle factors that hamper performance.

What is Screening?

Screening is the assessment of certain, pre-determined elements to assist in a number of outcomes. I like Chris Mallac's description of it as,

> "A continuum of athlete testing procedures, with injury prevention at one extreme and pure performance enhancement at the other" (Mallac).

A specific injury screen is familiar to many probably because they may have experienced it at the Physiotherapist's; a series of tests, pushing and pulling to determine where there is pain and weakness.
Performance screening is less familiar as it is not often done as it can limit potential by categorising the participant as inadequate in certain areas but it can be seen that the ability to do certain movements are essential in certain top-end sports.

Musculoskeletal screening would be somewhere in the middle of that continuum and that is what we are discussing – simple, easy replicable and measurable tests in range of movement, comparable strength and specific weakness that may point to a risk of an overuse injury.
Screening also includes recording and monitoring historical and on-going injuries even injuries not necessarily incurred whilst participating in high level sport. A knock to the knee whilst playing on their bike could cause a significant problem long term if not correctly managed.

Method

I am not an academic with access to the worlds libraries (Cochrane, CINAHL, PUBMed, Medline etc) so have had to use Google. I am pretty resourceful so manage to find a full article nine times out of ten and have not used any 'abstracts' to base my findings on.
I used the search terms:

- Sports screening in youths
- Sports screening in performance youths
- Sports screening in adolescents
- Screening adolescent sports injuries
- Screening climbing youths
- Sports specific physiological screening tools
- (Similar searches were carried out replacing the word screening with 'profiling' but the articles that were found related to physical profiling – not appropriate in this study)

I clicked links, followed threads and downloaded, copied and pasted to find the information to ensure that each article I have cited is genuine and from a reputable source. I apologise to the

authors for not contributing to the body that funded their research but I believe, like Ben Goldacre that all published research should be free to access (see Bad Pharma for full explanation).
It should be noted that there is not a huge amount of information out there, particularly if you focus on climbing. I should also point out that should you choose to do a more exhaustive search I wish you luck. I did exclude articles pre-2000 but there are many, many articles out there related to the subject and some of them appear to be written by academics with too much time on their hands and produce no significant findings. For example; Buechter and Fechtelpeter found, in their article: *Climbing for preventing and treating health problems: a systematic review of randomized controlled trials* (2011) that there was "very low quality evidence that therapeutic climbing compared to standard exercise therapy improved physical functioning".
I could have told you that.

Whilst it is obvious that I have 'cherry picked' articles i.e. chosen ones that support the case for screening adolescents, I had to draw the line somewhere. I am not intending to review all the articles that don't support it. There are a few where the results don't really show an improved outcome for the experimental cohort compared to the control cohort and many that point out the difficulties in delivering such a programme but generally the consensus is that screening is a positive thing and should be promoted.

Introduction

The benefits of sport and exercise are well documented and universally accepted and there has been a gradual increase in sports participation among adults over time however the majority of adults, 52% still do not engage in any sport at all (Sport England).
Children have a requirement to engage in sport in school and recent figures show that more than 90% of children do however that drops by around 20% when looking at sport outside of school (Gov, 2012).
The children participating in high level sport is much more difficult to define but a study has calculated the number of children that receive coaching on a weekly basis. If we assume that if a child is receiving 3 hours or more of coaching then they must be performance athletes and/or competitive it can be extrapolated that of the children who engage in sport outside of school that 23% to 37% of them are being coached depending on age group (North, 2007).
As this data is taken from the 10 most engaged in sports (swimming, cycling, football etc) it is difficult to estimate the number of children engaged in coached climbing weekly. One way of estimating it is to consider the number of children in a climbing squad at a climbing wall being about 20. If we assume an average of two major walls in each city of which there are 66 then there must be at least 2640 children receiving regular climbing coaching. Add to that walls in large towns, schools and youth clubs and the number soon begins to climb.
This would mean that there should be at least 500 qualified coaches out there and if we accept the need for athlete screening then we can see that more training is required.

> "Overtraining is the most common cause of overuse injury, the most effective way to prevent overuse injury is to ensure kids are being coached by qualified personnel (Micheli).

There is not a huge amount of evidence in the effectiveness of screening and an improvement in performance or reduction in injury although its necessity is not in doubt at all levels of sport. The

Preparticipation Physical Exam (PPE) in America assesses adolescents but as there is no universally accepted system it is acknowledged to have varying degrees of efficacy (Jordan, 2000). As well as this a medical preparticipation exam includes only information which is to *exclude* someone from participation on grounds of safety and tends not to assess their fundamental ability.
The development of Functional Movement Screening (FMS) in 1995 was an attempt to introduce a system that assesses specific core movement skills to highlight areas of strength and weakness and also identify problem areas. Using a simple scoring system from zero to three the participants perform seven fundamental movements (deep squat and lunge for example) on both sides.
This system has been widely adopted by personal trainers and sports and conditioning specialists and has been found to be a simple and effective measure of movement ability in adults (Cook & Burton).

General assessment and injury prevention has been part of sports for some time, we are all familiar with warming up and stretching routines but these tend to be as part of an overall approach to safety. For example, most walls teach falling off in bouldering as a nod to safety without addressing what is really required; namely that to fall of safely i.e. to prepare the body for repeated impacts and tumbles the body must be put through regular repetitions of these movements. Regular and frequent jumping and dropping training should feature in a squad's battery of skills.

There are physiological profiling in place for many sports and for climbing; research attempting to determine physiological differences between high level performance (elite athlete) and the normal population. My own research in 2009 identified a small but statistically significant difference between the finger flexor strength and extensor strength. Elite climbers demonstrated an imbalance with disproportionately strong flexors; a link between this and injury was not found (Brown, 2009).

The Rock Over Climbing Test (ROCT) was studied by Brent (2007) and showed a high correlation with climbing ability however there was no attempt to correlate with injury or biomechanics other than height and weight. Many other correlations have been found between simple tests and climbing ability (Wall, 2004. Bollen etc) including my own research into grip strength but the link between this and injury is less clear. In research I carried out over 2 years, measuring hundreds of climbers I determined that climbers who climb F6b/7a were more prone to injury than those who climbed a lower *or higher* grade (Brown, 2012).

There are also injury specific tests in regular use by the medical profession that are often adopted by coaches, for example:

- Balance as a predictor for ankle sprains
- Standing straight leg raise as an indicator of hamstring length and core strength.
- Modified Thomas test to measure hip flexor length.

But surprisingly few upper extremity ones are used by coaches in other sports……..

It is generally accepted that climbing causes more injury to the upper extremity than elsewhere with numerous studies identifying the hand then the shoulder as the most likely sites for injury (I have not cited them – there are loads. Google it). However, it has been found that,

> "Active prevention programmes that focus specifically on the upper extremity are scarce" (Maffulli, 2010).

Schoffl and Harrison (and Hochholzer) are regarded as the leaders in this field and have produced a raft of research and studies that support a clinical and systematic approach to teaching youngsters climbing. They concluded,

> "Knowledgeable and qualified personnel should carefully monitor training" (Schoffl, 2007).

Findings

Many sports deliver musculoskeletal screening as part of a pre-participation assessment. These are frequently delivered by doctors and physiotherapists but more often have become incorporated into an overall assessment as delivered by a trained and qualified coach. It is these training protocols that I am looking at.
The English Institute of Sport (EIS) Head of Sport Science and Medicine, Louise Fawcett writes, "We've been screening athletes for years. However, what we've been working towards over the past cycle is a profiling process which is far more performance-impact giving coaches and athletes both immediate feedback and information but also storing data which could help inform work we do […] down the line" (EIS).

In climbing there have been attempts to collect data nationally such as the BMC Injury Database and a similar system within the ABC currently but none have yet proven adequate to allow robust analysis. Local practitioners have also attempted to collect data; notably me and Carol Hayes in Northampton. Working independently with squads identifying risk and recording injury rates but again, due to the haphazard way of working and various limitations none of this data stands up to close scrutiny.
This is where profiling and screening can begin to develop and shape future practices.

EIS Physiotherapist Simon Spencer believes that a multi-disciplined approach to athlete profiling is essential with the coaches on the frontline. He describes athlete profiling as:

- Identification of risk factors that may predispose an athlete to injury
- Establishing links between physical characteristics and sustained injuries
- Individualised performance targets for injury rehabilitation
- Physical benchmarking for performance, power speed etc.

However even in established sports such as gymnastics this is only beginning to be introduced with only elite athletes in trampoline and artistic gymnastics having accessed their programme recently in time for the Commonwealth Games.
For a longer view we need to look elsewhere.

Fitness New Zealand's policy for all children taking part in any physical activity programme must take part in a pre-screening programme which should include a "Physical Activity Readiness Questionnaire (PAR-Q)" as well as consent and medical issues. They also insist on, "Any person working with children in an exercise capacity should meet the existing industry standards *plus* have completed a module specifically dealing with the unique needs of children" (FNZ). It can be seen that the UK, climbing coaching scheme, introduced in 2013 addresses this but the full extent of the

Fitness New Zealand's competencies/requirements (too long to list here) do highlight a few areas for development relating to this study, specifically:

- An understanding of physiology and growth (to include):
    - Physiological changes of growth
    - Development and maturation
    - Physiological responses to exercise
- Assessment/Exercise testing
    - Appropriate assessment types
    - Application of results to training activities and programming

Specific screening tools have been found to be predictors for injury. One review similar to this one but probably more extensive (Dallinga, 2012) found that general joint laxity and an imbalance between the hamstring and quadriceps strength were effective predictors of injury across many sports.

South African Rugby have produced very specific guidelines on the testing of athletes (Durandt, 2009) and includes anthropometric data (height, weight, BMI, skinfold thickness etc), fitness testing and strength, power and flexibility. Measurable tests include the sit and reach and straight leg raise as well as a 'Modified Thomas Test', used for measuring hip/quad flexibility. As well as this it includes physical benchmarking such as bent arm hangs, sit-ups, press-ups etc. However it should be noted that such a screening tool is for adults would not translate directly to children.

It seems that sports specific protocols are not widely used and it is worth considering why this might be. For a centrally driven and universally implemented system to work there needs to be an infrastructure in place to provide training, support, assessment, qualification, data collection and more. Each individual provider of the screening would be expected to deliver something specific yet, if a degree of professionalism and autonomy is to be expected certain adaptations and alterations of any prescribed protocol would have to be made.
The team of people that consider the health, wellbeing and performance of elite athletes need to consider what is best for each individual and having the tools to do so is different to setting out a specific requirement.
With this in mind it is useful to look to general texts of exercise testing.

Bruckner & Kahn state that medical screening before participating in elite sport is essential but that a full musculoskeletal screen would not be practical therefore they suggest that the purpose of a musculoskeletal screen should be, "to assess recovery from any previous injury and to assess the presence of proven (very few) or suspected risk factors for future injury" (Bruckner & Kahn). However they do highlight the paucity of evidence showing correlations between risk factors and injuries as well as the fact that multiple screens and assessments performed at many levels in different organisations "represent a waste of time and resources". They also discuss the problems of data collection, access and storage and also the frequent lack of follow up that occurs thus rendering the assessment and compiled data worthless.
A comprehensive protocol for an elite athlete medical screen is included within their book.

Perhaps the 'bible' on this subject is the Australian Institute of Sports (AIS) tomb, Physiological tests for Elite Athletes. Edited by Tanner and Gore it clearly outlines the case for athlete preparation, monitoring and testing as well as giving specific guidance on a wide range of suitable measures including anaerobic capacity, blood lactate thresholds and oxygen consumption as well as the assessment of physique.
It also includes specific testing protocols for a number of sports (Australian football, basketball, cricket, cycling, soccer, hockey, netball, rowing, rugby, running, sailing, kayaking, swimming, tennis, triathlon, volleyball and water polo).
None of these relate directly to climbing (as would gymnastics for example) but it gives such a comprehensive cover that it may be possible to extrapolate a suitable protocol for climbing.
What is interesting is their acknowledgment of the difficulties creating useable protocols that, "obtain high-quality data without placing excessive demands on the time or other resources of coaches." They state "Physiological testing is now more commonly combined with testing in other disciplines, particularly in field situations" which strengthens the case for coach led delivery of a protocol (AIS). However they also make a strong case for ensuring rigorous oversight and the involvement of clinical professionals as it is more likely to improve the analysis and application of data.
The book is extensive and a complete discussion of all the issues is beyond the scope of this short review but it does cover all the topics that need to be considered prior to commencement of a comprehensive sports screening protocol which are fully researched and referenced from a huge array of sources. It includes:

- Development and application of a suitable scheme
- Anatomy, anthropometry, physique and physiology (including data sets for sporting populations including youths in physique and strength)
- Psychological issues including anxiety and eating disorders
- Medical, clinical and coaching issues
- Scientific measurements (such as air displacement plethysmography, dual energy x-ray absorption body scans to name just two) and field based assessments such as strength, power and agility.

However the uniqueness climbing skills i.e. flexibility, finger strength, body tension are too specific to have much crossover with other sports particularly if we focus on well-known and documented injury prevalence. Grip strength and shoulder strength *and* flexibility are crucial (a protocol for shoulder mobility is discussed) but there are no protocols specific enough to use. The strength of this book is giving clear guidance on the implementation of such a protocol.

Conclusions

Setting out the case for musculoskeletal screening within performance, youth climbing coaching is fairly easy with no industry professional doubting its necessity and effectiveness. Implementing such a practice is more problematic with differences in opinion, practice ideas and variables in testing protocols. Allied with testing techniques, variations in programme design and difficulties accessing to appropriate training and information it can be seen that the current, localised initiatives whilst worthwhile are ultimately (and obviously) limited in scope.

A more centralised approached would provide a greater degree of parity across the country but again, there would be difficulties in accessing the information. Developing guidelines for screening in climbing coaching has begun and would be of great benefit to all coaches and climbers working in the high performance sector.
I see specific areas for development in the screening of young, elite climbers in the UK at the moment and I see particular problems.
Development areas would be:

- A nationally acknowledged requirement for the screening of youngsters engaged in elite sports.
- The development of a specific screening protocol and development of training processes
- A requirement for training and qualification for those coaches engaged in this process either through a modular system incorporated within the current qualification framework or CPD.
- The delivery of training

The Problem areas would be:

- Data collection and storage
- Analysis of data by appropriate personnel
- Expansion of a training delivery programme
- Monitoring of standards and guarantee of best practice as el as parity with other sports and national bodies

It is foreseeable that the implementation of screening protocols will continue to be adopted at a local level depending on the skills and resources each individual squad manager has at their disposal and what collaborations can be developed i.e. coaches, other walls, clinical staff, parents etc.

Signposting and guidance at a national level with easily accessible resources and knowledge would give coaches coming through the coaching scheme more confidence to attempt to deliver some form of prophylactic measures to protect their squad members.

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