SPORTS AND EXERCISE MEDICINE

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TABLE OF CONTENTS

Case Report
   – Matthew C. Miller* and Paul W. Macdermid

Opinion
2. Quality Health and Physical Education: Facilitating a Healthy Mind in a Healthy Body 111-113
   – Peter Whipp*

Case Report
3. Early Loading after Closed Wedge High Tibial Osteotomy for Knee Arthritis 114-117
   – Maksym L. Golovakha*, Emin Aghayev and Wenjamin Orlijanski

Research
4. Social Competence as a Role-Player in the Game between Motor Performance and Organized Sports Participation among School-Age Children 118-125
   – Britney Martin*, Brent Faught, Jian Liu, Miya Narushima, John Cairney and John Hay

Research
5. The Threshold of Physical Fitness in terms of Maximum Oxygen Uptake as a Predictive Factor for Achieving Prosthetic Walking in Elderly with Unilateral Trans-femoral Amputation or Hip Disarticulation 126-132
   – Mitsunori Toda, Takaaki Chin*, Noriaki Maeda, Atsushi Kitagawa and Hideshi Kohno
Case Report

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ABSTRACT

Critical power is emerging as an important indicator of high intensity endurance exercise capability. Little is known regarding its ability to predict performance during high intensity intermittent events such as Olympic format cross country mountain bike racing. Therefore, the purpose of this pilot study was to assess the validity of critical power and anaerobic capacity compared to the more traditional measure of power at physiological thresholds previously related to race performance. Five nationally competitive athletes (mean±s: age:31.4±9.3 years; mass: 70.8±9.5 kg; VO₂max: 63.8±7.0 ml•kg⁻¹•min⁻¹) volunteered for this study. Participants completed a cycle ergometry step test to exhaustion in order to determine the anaerobic threshold. On a separate occasion participants completed a 3-minute all-out test against a fixed resistance to determine critical power and anaerobic capacity. Laboratory data showed no differences (P=0.057) between the power output at the onset of blood lactate or critical power and neither related to anaerobic capacity (p=0.499 and p=0.344, respectively). Performance was measured via race data analysis gathered from a USA Cycling sanctioned race. Linear regression was used to assess the prediction of performance. Critical power predicts Olympic format cross country mountain bike performance (r²=0.943, p=0.006) to a greater degree of accuracy than anaerobic threshold (r²=0.785, p=0.046) or anaerobic capacity (r²=0.477, p=0.197) with less error (39.413; 76.526; 118.9 s, respectively). Therefore, the ability to sustain a high intensity effort for the race duration, determined via critical power rather than the onset of blood lactate, is likely more valuable to cross country mountain bike athletes than anaerobic capacity.

KEYWORDS: Blood lactate; Strength; Participants.

ABBREVIATIONS: XCO-MTB: Olympic format cross country mountain bike racing; LT: Lactate Threshold; FTP: Functional Threshold Power; RCP: Respiratory Compensation Point; CP: Critical Power; AWC: Anaerobic Work Capacity; GET: Gas Exchange Threshold; MSE: Mean Square Error.

INTRODUCTION

Olympic format cross country mountain bike racing (XCO-MTB) is a high intensity intermittent sport lasting between 60-90 min, taking in a variety of terrains or obstacles and requiring both high rates of aerobic and anaerobic energy production.¹ Un-typical of other endurance sports starting on mass, XCO-MTB requires maximal effort from the start to gain or hold positional advantage so as not to impair overall performance. As such initial field based research identifies that 82% of total race time corresponds to power outputs greater than the Lactate Threshold (LT) equating to 90% HRmax and 84% VO₂max.² While interesting such a holistic view of power data neglects key components of the sport such as the intermittent nature of propulsive and non-propulsive work done in combination with different components of strength or power.³ More detailed field based analysis acknowledges great variability in
recorded power output data due to terrain and frequency analysis identifying 42% of logged data to be greater than the anaerobic threshold.2

Exploratory research into the demands of such activities as XCO-MTB is usually accompanied by investigations determining the validity of performance, physiological or fitness variables used to predict performance. Typically, endurance sports have used various laboratory indices of blood lactate for determining physiological and/or performance capability.4 However, such testing is not readily available to all athletes or coaches due to cost of equipment and specialist training required. Demand in other sports such as team sports has led to the development of readily available, valid and reliable procedures such as the multistage fitness test and Yo-Yo tests to assess aerobic capability of performers. A more recent development in training monitoring technology has been the advent of affordable, valid and reliable power meter which have led to a performance assessment procedure for cyclists known as the Functional Threshold Power (FTP) field test.5 The FTP is reflective of the maximum power output that can be sustained for a 60 min period and has been shown to be equal to the power output associated with anaerobic threshold referred to as the onset of blood lactate threshold (P_{OBLA}) and/or Respiratory Compensation Point (RCP).4 Subsequently, FTP has been used for the determination of training zones and athlete capability, and is widely accepted in the cycling community as it can be continually estimated from training data.5 As such FTP’s applicability to XCO-MTB may be limited due to the intermittent, high intensity nature of XCO-MTB.2 Alternatively, Critical Power (CP) could be more meaningful as it demarcates the point between steady state and non-steady state exercise.7 To this end CP has been defined as the power output that can theoretically be sustained indefinitely when all work done is aerobic in nature and is accessed via tests to exhaustion of varying power outputs.8 From this data a hyperbolic Power-time (P-t) relationship can be plotted and CP therein identified at the asymptote of the curve.8 While work at or below CP can be completed at a metabolic steady state, any work above this intensity cannot, and will eventually lead to the attainment of VO_{2max} and thus exhaustion.9 Therefore, work done over CP can be presumed primarily anaerobic, is referred to as the W’ (previously referred to as Anaerobic Work Capacity (AWC)) and once this capacity is exceeded, exercise intensity cannot surpass CP.9 However, the W’ will begin to regenerate during periods of exercise at power outputs below CP per se, the W’ and CP concept has been best described as a battery that is alternately discharged (at any power>CP) and recharged (at any power<CP).10 Integrating both aerobic and anaerobic indices, CP could be both a valuable performance predictor and likewise a training tool, especially for high intensity intermittent sports like XCO-MTB. While significant positive relationships between CP and road cycling time trials has been established12 no study has ever compared CP to XCO-MTB.

Therefore, the aim of this study was to determine the relationship between a laboratory CP test, W’ and XCO-MTB performance in comparison with P_{OBLA}. We hypothesize that due to the high intensities demanded during XCO-MTB, CP will provide a more valid performance predictor than power output measures associated with the onset of blood lactate or W’.

METHODS

Participants

Five nationally competitive male XCO-MTB athletes (n=4 USA Cycling Category 1; n=1 Union Cycliste Internationale Elite; mean±s: age 31.4±9.3 years, mass 70.8±9.5 kg, height 171.6±5.1 cm, VO_{2max} 63.8±7.0 ml·kg^{-1}·min^{-1}) volunteered to participate in this study, which was approved by the University ethical committee.

All tests were completed with no less than 72 hours between tests over a three-week period. Participants were asked to come to each session having done no intense exercise over the previous 24 hours or ingested any food or caffeine in the previous three hours. Gas analysis was recorded using ParvoMedics TrueOne 2400 Metabolic Measurement System (ParvoMedics, Sandy, UT, USA) and blood lactate using Arkray Lactate Pro Test Meters (Arkray, Inc, Kyoto, Japan). All participants used their own bicycles for the XCO-MTB race.

Laboratory Trials

On the initial visit to the laboratory participants were weighed (kg), measured (cm) and the cycle ergometer (Lode, Groningen, The Netherlands, ) was set to individual requirements with any minor adjustments being made prior to the initial trial and fixed for subsequent tests. The first test session included a cycle ergometry test protocol involving a 3 min fixed effort at 120 W and increasing by 30 W every 3 min until volitional exhaustion. Throughout this test expired air was measured breath-by-breath and reduced to 10-second averages for the calculation of VO_{2peak} (highest value recorded for a 30 s average). Capillary blood samples were collected and analyzed during the last minute of each 3 min step for the determination of P_{OBLA}, indicated as the point at which blood lactate concentration exceeded 4.0 mmol·L^{-1}.

The second testing session involved a 3 min all-out test for the determination of CP.15 From values measured during the ramp protocol, 50Δ power was defined as the power output halfway between the Gas Exchange Threshold (GET) and VO_{2peak}. The ergometer was set using the linear mode so that the participants would attain 50Δ power upon reaching their preferred cadence (α=50Δ power/preferred cadence).4,16 Following a 3 min unloaded baseline epoch, participants were asked to accelerate their cadence to approximately 110 rpm during the last 5 s preceding the all-out period. Participants were encouraged to maintain the highest cadence possible during the 3 min all out portion of testing through strong verbal encouragement, but no indication of elapsed time was given. CP was determined as
the mean power during the final 30 s of all-out testing, and W’ (kJ) as the total of all work completed above this value. CP and P_OBLA were recorded relative to body mass (W•kg⁻¹) as relative measures have been shown to be more reliable for predicting XCO-MTB performance.¹⁷

Field Test Trial

Participants completed a regional mass start XCO-MTB competition (Greenbrier Challenge, American Mountain Bike Challenge, Mid Atlantic Super Series, Boonsboro, MD, USA) sanctioned by USA Cycling. Each lap was 7.5 km, had 266 m of elevation gain and was of moderately technical terrain (Figure 1). Quantification of performance via race time using radio frequency identification timing chips (Mid Atlantic Timing, Downingtown, PA, USA). As participants completed this race as part of their own racing schedule and were given no protocol of which to adhere before, during or after the race regarding pacing or strategy. All participants completed the race without mechanical incident on their own bicycles. Lap times were reduced to mean time across four laps, as XCO-MTB athletes have been shown to have little between-lap variation during races.¹⁸

Statistical Analysis

All data is expressed as mean±SD unless otherwise stated. Statistical differences between CP and P_OBLA were assessed using Students t-test. Linear regression model were used to evaluate the coefficient of determination and standard error when using relative measures (W•kg⁻¹) of CP and P_OBLA in the prediction of mean race lap time. Mean Square Error (MSE) was calculated as the residual sum of squares divided by the degrees of freedom and used to determine estimation error. Estimation error (Error) was calculated as the square root of MSE and is expressed in unit time (s).

RESULTS

Power data (1 Hz) collected during the 3 min max test and the interaction between CP and W’ are expressed as mean±95% CI for CP and W’ for all participants (Figure 2). Mean±SD values for both P_OBLA and CP showed no overall difference for relative power output (3.9±0.7and 4.4±1.0 W•kg⁻¹, t⁰(d)=2.468, p=0.057). However, P_OBLA and CP were significantly correlated (r=0.943, p=0.016) with each while W’ (14.27±3.96 kJ) was found not to relate to either P_OBLA (r=0.405, p=0.499) or CP (r=0.543, p=0.344).

Race data showed considerable variation between participants with mean±SD overall time of 6852±569 s with a range of 6040-7268 s with lap times equal to 1713±142 s.

Comparison of laboratory data with race performance indicates that CP is better able to explain variance in mean lap time than POBLA and W’ (r²=0.943, p=0.006; r²=0.785, p=0.046; and r²=0.477, p=0.197, Figures 3A-3C). Error associated with performance estimations from mean lap time are also less when using CP than P_OBLA or W’ (76.3; 39.4; and 118.9 s), respectively.

DISCUSSION

The purpose of this study was to determine the relationship between a laboratory CP test, W’ and XCO-MTB performance in comparison with P_OBLA. The main findings show: (i) relative measures of aerobic capacity (CP and P_OBLA) are better predictors of XCO-MTB race performance than laboratory measures of anaerobic capacity (W’); (ii) CP can explain more variance in performance, with less error than P_OBLA.

CP has previously been shown to occur at a higher work rate than the maximal lactate steady state¹⁹,²⁰ while being signifi-

Figure 1: Lap outline and profile with Start/Finish area indicated.
significantly correlated to $P_{OBLA}$. The results of this study support the strong association of XCO-MTB performance with $P_{OBLA}$ previously reported. However, CP predicted performance to a greater extent (Figures 3A-3B). This is due to the greater power output ($0.54\pm0.46, 95\%\ CI\ -0.03\ -1.11\ W\ kg^{-1}$) associated with CP compared to $P_{OBLA}$ and the higher intensity sustained during XCO-MTB. Therefore, prescription of training zones determined from laboratory testing for CP would increase the training stimulus response compared to $P_{OBLA}$. Theoretically, the hyperbolic P-t relationship developed through the measurement of CP offers a more sensitive insight into the changes in fitness brought about through training. Specifically, XCO-MTB performance would benefit from either sustainable aerobic performance (CP) and/or anaerobic capacity ($W'$) improvements.

**Figure 3:** Scatter plot of lap time versus measures of A. $P_{OBLA}$; B. CP; and C. $W'$, with regression equation and correlation coefficient displayed.

Power profiles reported for XCO-MTB highlight the importance of both aerobic and anaerobic indices of performance. Additionally both anaerobic and intermittent tests have been shown to predict performance to a greater extent than steady state tests. However, while associated with various other thresholds, CP delineates the boundary between steady state and non-steady-state exercise by way of utilizing both steady state and non-steady state variables. Interestingly, the non-steady state component ($W'$, Figure 2) previously referred to as AWC was a poor predictor of overall XCO-MTB performance (Figure 3C) and did not relate to either of the steady state variables within this study. This is an aspect that requires further investigation given the frequency of occurrence of maximal and supra-maximal efforts occurring during XCO-MTB races. One possibility is that the ephemeral nature of supra-maximal efforts while race defining based around positional advantage is minimal with regards to physiological contribution. Indeed, total anaerobic contribution, including the start effort, is less than 5% of overall race duration. Consequently, the results from this study show that the upper limit of XCO-MTB performance is dictated by CP with less regard for the $W'$. Corroborating this is the fact that the completion of intermittent work such as that seen in XCO-MTB is highly dependent on aerobic metabolism and type 1 muscle fibres. As such, it might be prudent that future research investigates the relationship of much shorter bouts of supra-maximal efforts and the capability to reproduce such efforts in relation to XCO-MTB performance.

**LIMITATIONS**

Using a one off race that was part of participants’ competition schedule meant that each participant was appropriately motivated and had no intervention with regards to preferred strategy. This increases the validity of the study. However, this did result in a low number of available participants and as such reduces the overall power of the results.

Efficacy of laboratory testing using different equipment in regards to real world performance is always questionable. The tests used within this study, could quite easily be completed in the field with athletes own power meters, and as such may be more valuable to athletes and coaches. CP and $W'$ can be reliably determined by plotting a curve from best power-for-time results, and has been shown to equate to laboratory estimates like the 3 min all out test used in this study. Succinctly, we would expect the given results to be similar to those collected from field measures of the same tests, but this needs confirming. The participants in this study were nationally competitive (USA Cycling registered) XCO-MTB athletes and as such had lower mean $V_{O2\max}$ ($63.8\pm7.0$ versus $78.3\pm4.4\ ml\ kg^{-1}\ min^{-1}$) in addition to greater body mass ($74.5\pm9.5$ versus $65.3\pm6.5\ kg$) compared to internationally competitive XCO-MTB athletes, respectively. While this could be viewed as a limitation of the present investigation, similar correlates to performance have been observed among elite and amateur XCO-MTB athletes. As such we are confident the results are transferable to a range of abilities, but this needs confirming. Further, results of this study should be corroborated among a more homogenous group of athletes.

**CONCLUSION**

This study set out to assess the impact of aerobic and
an aerobic capacity on XCO-MTB bike performance. As such, only the aerobic variables measured related to performance, in which critical power displayed greater importance than the onset of blood lactate threshold. Future work needs to assess the efficiency of such findings over a more diverse group and explore the multi-linear relationship between indices of XCO-MTB performance.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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Quality Health and Physical Education: Facilitating a Healthy Mind in a Healthy Body

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In the past, the Greek ideal; “Mens sano incorpore sano”, stressed the importance of having a healthy mind within a healthy body. In the current high-tech sedentary society, this is increasingly an outcome to which we all should aspire. This communique highlights the importance of a comprehensive educationally-based and strategical approach to wellness that values the role of the health and physical educator.

An effective reduction strategy in those living a sedentary lifestyle is seen to lie within the domain of school and community programs that promote regular Physical Activity (PA) and associated health understandings. Importantly, there is a large body of evidence indicating that Physical Education (PE) classes are a significant setting for endorsing the benefits of a physically active lifestyle and for promoting engagement in PA both within and outside school. It is widely acknowledged that adolescents’ experiences in PE are an important factor in their physical activity levels; but, it also is a critical time period for shaping life-style exercise and health related habits. Furthermore, PE and the activity generated facilitate disease prevention, decreased morbidity and premature mortality, as well as improved mental health. Despite the health-enhancing effects of regular physical activity, adolescent participation rates typically fall below recommended guidelines.

The accountability of PE and indeed health education Health and Physical Education (HPE) should be viewed through the lenses of student outcomes. Accordingly, alongside reasons for physical health, HPE outcomes should facilitate the primary development of physical skills, lifestyle physical activity patterns and health literacy. Positive HPE experiences should also access opportunities for students to develop skills related to management of self and others, interpersonal skills, knowledge and understanding, leadership, tolerance, self-esteem and self-efficacy. Somewhat unique in the school menu of subjects, quality HPE provides opportunities to develop cognitively, spiritually, socially, emotionally, and physically – all in a one-stop-shop!

While it is acknowledged that HPE represents a complex learning environment, the efficacy of contemporary HPE has been debated. However, it is universally accepted that student’s interests, as well as readiness and ability levels mandate the need for differentiated practice. Significant differences in (a) the developmental level of learners, (b) their stages of learning (i.e., beginner, intermediate, and advanced), and (c) the diverse nature of the content that needs to be covered, reiterate that a ‘one program fits all’ approach does not encourage optimal student development. Exemplifying this point, low competence children have displayed greater physical activity (PA) effort in programs that de-emphasize competition and use teacher centred teaching strategies. Moreover, gender and the motives for engaging in physical activity (PA) appear to differ between children who participate in structured sport outside of school and those who are not.

Differentiation involves the teacher tailoring content, process/support, and product in response to their students’ needs. Importantly, it reflects a level of autonomous support,
where students’ motivational regulations are enhanced through the satisfaction of three basic psychological needs for autonomy, competence, and relatedness. The need for autonomy represents one’s desire for input, choice, and a sense of agency or volition regarding one’s pursuits. Competence reflects one’s desire to feel capable with respect to one’s environment, and relatedness refers to the desire to feel connected to, and understood by, significant others. When an individual feels that their needs are satisfied, they display relatively greater self-determined motivation, which in turn supports more positive achievement behaviour. While perceived support is clearly multifaceted, some research suggests that students’ perceptions of relatedness support in PE are a stronger predictor of self-determined motivation than perceptions of autonomy and competence support. Irrespective, the relationships that the teacher builds with their students through displaying relatedness behaviors (see Table 1), be it in the academic setting or as in this case HPE, are powerful facilitators of learning outcomes.

In addition to the valuable outcomes of HPE, a recent Australian Federal Government initiative will realize the implementation of a $100 million nationwide sporting program in schools. It will involve more than 30 sports, delivered by accredited coaches, with an explicit intention to address a perceived childhood inactivity, obesity and motor coordination conundrum. Whilst the provision of school-aligned sporting activities may serve to provide opportunity for students to be active, one can only ponder the potential missed opportunities. As discussed earlier, quality health and PE implemented in a differentiated framework, can access a broad spectrum of desirable outcomes. After school sport is clearly not HPE and a coach is not necessarily a quality educator. Potentially bereft of the teacher-student relationship, educational foci, cross-curricula underpinnings, and differentiated practice; by simply dropping kids into competitive games we may further disenfranchise the young people that we seek to serve. The success of health promotion strategies is enhanced when it is: multi-modal; strategically aligned to goals; interrelated with the school curriculum, teaching and learning, the school ethos, policy and environment; and, collaboratively developed with family and community partnerships. In sum, school sport delivered in isolation to a child’s education is a blunt, unsophisticated intervention instrument. A quality physical educator, working with children to develop autonomous motivation through individualized relationships remains central to the facilitation of a healthy mind in a healthy body.

<table>
<thead>
<tr>
<th>Teacher Actions</th>
<th>Relatedness Supportive Qualities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genuine Listening</td>
<td>• Listen to students and acknowledge their individual perspectives.</td>
</tr>
</tbody>
</table>
| Catch Students Being Good | • Encourages all students – equitable support.  
• Values effort to learn and improve.  
• Enthusiastic about the content and the student achievements.  
• Belief in the students: Teacher and Peer RISE (relation-inferred self-efficacy).  
• Encourages and motivates. |
| Safe and Enjoyable Classes | • Teacher mood, teaching style, promoting teamwork and things that the teacher does to make actual class time a positive experience.  
• Set and inform students of high, realistic expectations. |
| Differentiates | • Provides a pedagogy to match the task, students’ needs and the desired learning outcomes.  
Not one style or content fits all.  
• Provides choice. |
| Switched-on | • Brisk pace – purposefulness.  
• Gives sufficient and appropriate opportunities to learn.  
• Teacher demonstrating ability to perceive and respond; to be conscious of class events, picking up on emotional cues from the students.  
• Belief in themselves as an educator. |
| Connector | • Students feeling comfortable enough to hold conversations, make jokes, ask questions or address issues with their teacher.  
• Have PA, H, PE, sport & lifestyle – as a common connector.  
• Asking students questions/conversing with students about things unrelated to class, “getting to know” students better.  
• Students develop ownership when they contribute to planning. |
| Respectful | • Meaningful and respectful tasks – outcome focussed.  
• Have mutual respect (between student-teacher).  
• Provides a meaningful rationale for the learning tasks on offer. |

Table 1: HPE teacher actions that serve to connect and motivate students.
REFERENCES


Case Report

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ABSTRACT

Operative treatment approaches for the arthritis in the medial tibiofemoral compartment combined with a varus deformation of the knee are closed wedge high tibial osteotomy or knee arthroplasty. In contrast to the knee arthroplasty, tibial osteotomy maintains primary the function of natural knee joint. However, the limitations of the method are the necessity of postoperative immobilization, late term of loading and long period of functional recovery. The study on early loading after closed wedge high tibial osteotomy as the treatment of knee arthritis was initiated. Two group of different postoperative rehabilitation approach were allocated. The first group included 22 patients in whom the loading was applied after 6th postoperative week, and the second group included 15 patients with early weight bearing at 3rd-5th postoperative day. Estimation of complications and comparison of the results of the treatment in two groups was carried out. The short- and long-term results of the treatment in the both groups showed similar distribution of good and poor result without significant differences. Studying rehabilitation dynamic, early loading allowed for faster postoperative functional recovery. No statistically significant differences regarding postoperative complications between the groups were observed. Our results indicate that early weight bearing after high tibial osteotomy does not worsen process of rehabilitation and result of the treatment. The absence of statistical differences regarding postoperative complications indicates the safety of the approach. In conclusion, we assumed that after closed wedge high tibial osteotomy the early postoperative loading is an advantageous rehabilitation approach in comparison with the late loading due to a faster functional recovery and a shortening of the patient hospitalisation. Nevertheless, further multi-patient studies on this approach with similar long-term follow ups are necessary.

KEYWORDS: Knee; Arthritis; High tibial osteotomy; Loading; Closed wedge.

INTRODUCTION

Treatment of gonarthritis by closed wedge high tibial osteotomy is a widely applied method in practice of modern orthopaedics. Numerous scientific works, which recently appeared in the periodic literature, confirm both high interest to the given problem and efficiency of this method. The discussion deals basically with the choice of correct indications for the osteotomy, and also with selection of a method for its carrying out.

Currently, high tibial osteotomy is recognised as a confident alternative to total knee prosthesis. At first sight, total knee prosthesis is more advantageous. It has a short term of postoperative rehabilitation, and provides more precise positive outcome of the treatment. In contrast, the basic advantage of closed wedge high tibial osteotomy within the treatment of knee arthritis is the opportunity to maintain the function of natural knee joint. It is well documented
that the choice of closed wedge high tibial osteotomy by correct management of its indications gives high density of successful results of treatment.4,7

By the combination of arthritis in the medial tibiofemoral compartment and varus deformations of the knee, the traditionally applied treatment is the closed wedge high tibial osteotomy through external access with osteosynthesis by staples.2,3 The limitations of the method are the necessity of postoperative immobilization, late term of loading and long period of functional recovery. Furthermore, it is necessary to note a small range of correction for the varus deformation. From different medical sources, the maximum of correction makes between 15 and 25°.2,4,7

The studies performed in our department on early loading after arthroscopy and total knee arthroplasty have forced us to reconsider the approach for postoperative rehabilitation after closed wedge high tibial osteotomy. The following study describes the effects of early loading after closed wedge high tibial osteotomy as the treatment of gonarthitis.

MATERIAL AND METHODS

The study included 37 patients, which were treated at our department by closed wedge high tibial osteotomy during the period between 1997 and 2004. All the patients were surveyed in dynamic. Thirty three were female and four male. As the indication for the operation was knee arthritis with primary lesion of the medial tibiofemoral compartment. A retrospective analysis of the treatment results of the patients was performed.

For the estimation of the joint condition a knee x-rays with functional loading (standing) were carried out prior to operative treatment. The roentgenograms formed a basis for planning and calculation of axis correction. Subsequently, operations were carried out under general anesthesia.

At the first stage, an arthroscopy checking joint surfaces, patella position, synovial capsule, presence of intraarticular bodies, the condition of meniscuses and ligaments was performed and reasons for flex contracture were assessed. Removal of the intraarticular bodies, partial resection of the meniscus, local synovectomy and fossa plastic were carried out for restoration of the full extension.

The operation using the external curved approach to the proximal tibia made the second stage. The osteotomy was performed by a chisel or oscillation saw according to the preoperative plan. The osteosynthesis was carried out using staples. For prevention of postoperative complications antibacterial prophylactic and Fraxiparin-forte for 14 days were applied.

According to the postoperative period two different groups of patients were allocated. The first group included 22 patients (two male and 20 female) in the age between 38 and 78 years who were operated during the period from 1997 till 2000. In this group isometric gymnastics began on the second postoperative day and immobilization was used within four weeks. The splint removal was followed by rehabilitation course. Partial weight bearing was allowed after 6th-8th and full bearing after 10th-12th postoperative week.

The second group included 15 patients (two male and 13 female) in the age between 42 and 68 years which were treated during the period from 2002 till 2004. The rehabilitation course in this group began also with isometric exercises on the second postoperative day and immobilization was used within two or four weeks. Partial weight bearing was allowed already after 3rd-5th postoperative day. Walking with a stick began after 4th-6th postoperative week depending on physical condition of the patient. As immobilisation, in two patients a brace was applied from 7th postoperative day. For all other patients a plaster cast was used during all period of fixation.

For the knee assessment at follow ups a standard “Knee Society” scale was applied.8 For the estimation of the effect of early loading after the osteotomy the analysis of the postoperative period and, importantly, of the early complications were performed.

The short-term follow up for both groups was performed on the 4th postoperative month and one year after operation. The long-term follow-ups for the first group lay between 5th and 8th and for the second group between 1st and 3rd postoperative year. Statistical differences of the treatment results in the groups were assessed using Student’s t-test (two tailed, α=0.05).

RESULTS

In the first group of patients the estimation of the short-term results using the “Knee Society” scale showed (on the average) following points combinations: preoperative - 98 points; 4th months follow up - 145 points and one year follow up - 167 points. In the second group of patients comparable points combinations were documented: preoperative - 102 points; 4th months follow up - 167 points and one year follow up - 172 (Diagram 1) (Figure 1).

Diagram 1: The results of the treatment of patients using the “Knee Society” score at the short-term follow ups.
The long-term results of the treatment in the first group (late loading) of the patients were excellent in four, good in 12, satisfactory in four and unsatisfactory in two patients. The long-term results in the second group (early loading) of the patients were excellent in four, good in eight, satisfactory in two and unsatisfactory in one patient (Diagram 2) (Figure 1).

The number of complications after operations in researched group of patients was not too large (Table 1). Significant differences in complications between the first and second group of patients were not seen (Table 1). Thus, application of early weight bearing after closed wedge high tibial osteotomy has not led to increase in the number of postoperative complications.

<table>
<thead>
<tr>
<th>No.</th>
<th>Complication</th>
<th>Late loading</th>
<th>Early loading</th>
<th>Total</th>
</tr>
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<tr>
<td>1</td>
<td>Deep venous thrombosis</td>
<td>1</td>
<td>1</td>
<td>2</td>
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<tr>
<td>2</td>
<td>Delayed union</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Recurrence of the varus deformations</td>
<td>3</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>Total</td>
<td>5</td>
<td>3</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 1: The distribution of postoperative complications after closed wedge high tibial osteotomy between the two studied groups.

DISCUSSION

Currently, development of techniques and approaches for operative interventions in orthopaedics goes on the way of achievement of the shortest possible rehabilitation period, which is mainly due to the high hospital costs for patients stay.

The idea for this study was born after introduction of early full loading after total hip and knee arthroplastic in our clinic. This technique has been borrowed from our German colleagues, and it has repeatedly passed check, both on efficiency and on safety.9 Observing patients after total hip arthroplasty, we concluded that early loading does not slow down but accelerates process of functional recovery of the joint. Similarly, considering our experience with knee arthroscopy, which was initially, before 10 years, followed by late weight bearing on the 4th or even 10th postoperative day and currently is the subject of one day hospitalisation, an early loading is advantageous.

Additionally to these ideas, the other reason for this study was the fact that three of our patients have began with early loading without our advice and in contrary to our recommendations after they were discharged from the hospital (within the 2nd postoperative week). At the follow up of the 4th postoperative week each of these patients showed a good range of motions and a good radiologically confirmed consolidation of the osteotomy.

The study was performed on two groups of patients with comparable age and sex distribution. The indication for the treatment of knee arthritis by closed wedge high tibial osteotomy was carefully examined in all patients.

The comparative analysis of functional recovery in the first and second group of patients showed that early loading allowed for faster postoperative rehabilitation. This was confirmed by the computer system for gait analysis. This is also indicated by significantly different (p<0.05) results in the two groups at the 4 months follow up (Diagram 1).

Our short- and long-term results of the treatment in the both studied groups showed similar distribution of good and poor result without significant differences. This indicates that early weight bearing after high tibial osteotomy does not worsen process of rehabilitation and result of the treatment. In contrary, early loading allowed for faster postoperative functional

Figure 1: Case report: a 51-year-old male was treated using closed wedge high tibial osteotomy. Immobilization was 2 weeks. Partial weight bearing was allowed from the 3rd postoperative day. The images shows a) the preoperative x-ray; b) the x-ray performed at the second postoperative day; c) the x-ray carried out at the follow up of 8 years; d) the functional result of the patient at the 10 years follow up.

Diagram 2: The results of the treatment of patients using the ‘Knee Society’ score at the long-term follow ups.
recovery. The absence of statistical differences regarding postoperative complications indicates the safety of the approach.

In the presented study, the second group of patients, in which the early postoperative loading was applied, included 15 patients. Furthermore, long term follow ups for the groups were different. Although, in comparison with the group of late loading, good results of the treatment and even faster functional recovery of the patients with early loading was documented, further studies using the described rehabilitation approach are necessary.

In conclusion, based on our results we assumed that after closed wedge high tibial osteotomy the early postoperative loading is an advantageous rehabilitation approach in comparison with the late loading due to a faster functional recovery and a shortening of the patient hospitalisation. Nevertheless, further multi-patient studies on this approach with similar long-term follow ups are necessary.

CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare.

CONSENT

The authors have obtain written informed consent from the patient for submission of this manuscript for publication.

REFERENCES


Social Competence as a Role-Player in the Game between Motor Performance and Organized Sports Participation among School-Age Children

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ABSTRACT

Lifestyle choices from childhood, such as being physically active, track into adulthood. A key factor that influences a child’s likelihood of being healthy is their level of social competence. Social Competence (SC) is the interaction between the environment and biologically determined abilities and is shaped by social support systems. An underdeveloped SC increases a child’s risk of unhealthy lifestyles as an adult as they believe themselves incapable of adjusting their habits. Children with biologically determined inabilities, such as motor impairments, have been demonstrated to have an activity deficit, particularly in sport participation. The relationships between social competence, motor performance, and physical activity are largely unexplored. The purpose of this paper is to examine the role that SC plays as a mediator between Motor Performance (MP) and organized sports participation in preadolescent children. This sample is 1958 sixth grade children (50.2% males) taken from the Physical Health Activity Study Team (PHAST) study in Ontario, Canada. Organized sport participation was determined using the Participation Questionnaire, MP was established using the short form of the Bruininks-Oseretsky Test of Motor Proficiency (BOTMP) and SC was determined through Harter’s Self-Perception Scale. The results indicated that MP and SC are independent predictors of sport participation. Children with low MP and low SC were at significantly greater risk of low sport participation (ORmales=2.82; ORfemales=2.41). Children with low MP and high SC (ORmales=1.04; ORfemales=1.41) or high MP and low SC (ORmales=1.12; ORfemales=0.98) revealed no increased risk of low sport participation. SC plays an important role in organized sport participation during childhood and ameliorates the risk of inactivity associated with lower MP. With high SC diminishing the risk of low sport participation from low MP, a child’s risk of low physical fitness may be subsequently reduced and therefore may be an important consideration for activity promotions.

KEYWORDS: Social competence; Physical fitness; Motor performance; Sport participation.

ABBREVIATIONS: BOTMP: Bruininks-Oseretsky Test of Motor Proficiency; SC: Social Competence; MP: Motor Performance; PHAST: Physical Health Activity Study Team; DCD: Developmental Coordination Disorder; DSBN: District School Board of Niagara; CIHR: Canadian Institutes of Health Research; PQ: Participation Questionnaire.

INTRODUCTION

Developing a healthy lifestyle in childhood is crucial for establishing those habits in adulthood and thereby reducing the risk of future disease. Evidence has accumulated demon-
stratifying that lifestyle choices established in childhood are maintained in adulthood. In Canada, as few as 7% of children and youth meet the recommended levels of 60 minutes of moderate-to-vigorous physical activity for children (5-11 years) and youth (12-17 years) for the promotion and maintenance of health. The trend toward increasingly sedentary lifestyles in childhood has been linked with a similar increase in prevalence of childhood obesity. Children who are obese display lower levels of confidence in their ability to conquer physical activity barriers, leading to a preference for a sedentary lifestyle. Physical activity patterns track into adulthood along with an increased risk for overweight and obesity as a result. Reduced physical activity is also associated with lower psychological well-being and social skills among children and adolescents. This relationship further highlights the importance of children developing active lifestyles to build a healthy foundation for adulthood.

This study investigates the relationship between social competence, motor performance, and physical activity. For the purpose of this study, physical activity is viewed from a behaviouralist perspective and lies in the type of activity, the environment that the activity took place, and the volitional aspects of the child’s activity. The particular focus here is on a significant component of children’s physical activity – organized sport participation.

Developmental Coordination Disorder (DCD) is defined as a chronic and normally permanent condition found in children characterized by motor impairments that interfere with their daily physical activities, as well as academic achievement. Depending on the rigor of diagnostic criteria applied, a prevalence of 3-9% of school-aged children has been reported making DCD one of the most common childhood disorders. Furthermore, poorer motor performance at a younger age significantly impacts a child’s physical activity levels in later years, emphasizing the importance of increasing physical activity levels at a younger age so the decline in activity is not as detrimental.

Social competence (SC) is the interaction between one’s environment and their biologically determined abilities and is shaped by social support systems. Gender is a focal feature associated with physical activity and social competence, with differing values that boys and girls place on physical activity, particularly with sport participation. External (social) and internal (self-perceptions) pressures account for the participation choices of being active in boys; however, girls with an absence of either an external or internal pressure do not greatly change their participation over time. Due to the various values that boys and girls place on physical activity, it is important to recognize that it is more than just motor competency that affects their physical activity participation.

Because of our limited knowledge on the potential moderating role of social competence between motor performance and physical activity, these interrelationships may have been overlooked. In order to develop a full understanding of the development of physical activity patterns in childhood, the relationships between motor performance, physical activity, and social competence warrant exploration. Therefore, our central research question is: Does social competence alleviate the risk of low sport participation in boys and girls with lower motor performance? This understanding will inform the development of more successful physical activity promotion programs particularly for those with poor motor performance.

**MATERIALS AND METHODS**

This was a cross-sectional investigation using data from a longitudinal study by the Physical Health Activity Study Team (PHAST). PHAST was funded by the Canadian Institutes of Health Research (CIHR) and followed students for six years from grade 4 (2004) to grade 9 (2010) in the District School Board of Niagara (DSBN). The PHAST study received Research Ethics Board approval from Brock University and the DSBN. This investigation examined data from the winter term of Grade 6 in 2007 when the testing and training protocols were established, assembly of a cadre of trained assistants was done and pilot testing occurred in the fall of 2004. This wave was chosen as students were familiar with the study protocols, scores of the BOTMP were available for all participants and the recall period of physical activity contains the entire school year.

The study population included 2211 children in the sixth grade with 2035 (92.0%) who received motor testing. However, 77 children were excluded from the multivariable models due to missing data from key outcome measurements, leaving a total of 1958 subjects for the investigation, 982 males and 976 females. The mean age of children was 11.91 years.

Organized sport participation is the main outcome variable in this analysis. In this investigation, activity levels were evaluated using the Participation Questionnaire (PQ). This is a valid and reliable instrument for use in this population and includes a section devoted to organized sports. Information was collected on children’s participation in sport teams, clubs, school sports, and sports and dance lessons over one year. The PQ measures activity units, defined as participation in a discrete activity involvement in the above mentioned activities, with both school and community settings reported. This score does not reflect duration or intensity, just participation. The PQ has displayed construct validity with expected gender differences, overweight and obese status, and urban/rural differences present, along with consistency of test-retest reliability of 0.81. The PQ was administered in the regular classrooms at school.

Motor performance is a predictor variable in this investigation. For the purpose of this investigation, children will not be categorized based on diagnosis of DCD based solely on motor performance. We will explore the relationship in children within the entire spectrum of motor capabilities. The
Bruininks-Oseretsky test of motor performance (BOTMP) is the most commonly used standardized test for motor performance, examining the full scope of motor ability and has been used as an assessment tool for motor skills in children aged 4.5 to 14.5 years. The short form of BOTMP will be used for this study and has also been validated against the long form of the test with correlations between 0.90 and 0.91 among children ages 8 to 14 years. This test contains eight subsets including running speed and agility, balance, bilateral coordination, strength, upper-limb coordination, response speed, visual-motor control and upper-limb speed and dexterity, along with 46 separate items to ensure a comprehensive index of motor proficiency. BOTMP is a well-established valid and reliable test for movement skill ability. The short form of BOTMP was administered in the school gymnasium and a rank-percentile calculated for each participant. Children were then placed into quartile groups and high/expected competence (3rd and 4th quartiles) low/impaired competence (1st and 2nd quartiles) groups.

Social competence is the moderating variable in this investigation. In this investigation, self-perceived social competence is of interest where the responses reflect the child’s own ability to engage in effective social interactions. The social competence sub-scale of the Harter Self-Perception Scale (which was completed at the same time and in the same manner as the PQ) was used for this analysis. The subscale of social competence described the child’s amount of friends, how likeable they are, and how important they feel they are within the classroom setting. It is important to note that these scaled items are demonstrating the child’s personal perceptions, compared to a clinical measure. A z-score was calculated for each child to describe the child's personal perceptions, compared to a clinical measure. A z-score was calculated for each child to describe the child’s personal perceptions, compared to a clinical measure.

There are many variables that may confound the relationship between motor performance and physical activity, including fitness, ethnicity, pubertal stage, SES, BMI and gender. The PHAST study was not permitted to gather data regarding the participant’s ethnicity; however the DSBN has a distinct homogeneity among their students with the large majority being Caucasian. Parental education is commonly used as a partial measure of SES; therefore this was used as a proxy measure in PHAST and was taken into consideration.

Table 1 provides a detailed breakdown of our key variables separated into gender. The purpose of the analyses is to distinguish the interrelationship between organized sport participation, motor performance and social competence. Comparative t tests on sport participation were used to determine if there are any differences between motor performance quartiles or social competence groups. Multiple regression models were run on sport participation measure as the dependent variable to show the initial relationship of the key variables, as well as the impact from potential confounders. Logistic regressions were then performed to show the role that social competence plays on the well recognized relationship between physical activity and motor performance. Four sets of odds ratios were used to exemplify the moderating role of social competence on the existing relationship between motor performance and sport participation. Each set of odds ratios were compared with adjusted odds ratios with the previously mentioned confounders. All statistical analyses were completed using SAS 9.3. Assumption checks were done on linearity, independence, homoscedasticity and normality, with each measurement tool being previously validated through previous literature. Normality checks have been done in all key variables with no variable being normally distributed (p<.005). However, due to our large sample size, we continued the investigation with caution. Organized sport participation measurement was very highly skewed, which led us to square rooting the activity values.

### RESULTS

Table 2A provides mean organized sport participation values by gender and motor performance quartiles. Table 2B provides mean organized sport participation values by gender and social competence groups. ANOVA tests for motor performance and sport participation on males and females computed F values of 27.51 and 18.18, respectively. All p values were less than the significant levels of 0.05, with comparative differences being based on Bonferroni post-hoc test. In males, significant differences in organized sport participation were in all motor performance comparisons except when comparing 1st and 2nd quartile. In females, organized sport participation had significant differences in all comparisons except when comparing the 2nd motor performance quartile to the 1st and 3rd quartiles. T-tests for social competence and sport participation were performed on males and females with t values being -7.16 and -8.37, respectively. All p values were less than the significance levels of 0.05. Based on visually and statistically comparing the mean organized sport participation measurements between high and low social competence groups, the high social competence group had significantly higher sport participation compared to the low social competence group in both genders.

<table>
<thead>
<tr>
<th>Table 2A: Descriptive characteristics by males and females.</th>
<th>Males (n=982) Mean (SD)</th>
<th>Females (n=976) Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (years)</strong>†</td>
<td>11.92(0.35)</td>
<td>11.90(0.34)*</td>
</tr>
<tr>
<td><strong>BMI (km/m2)</strong>£</td>
<td>19.95(3.94)</td>
<td>20.14(4.11)</td>
</tr>
<tr>
<td><strong>Organized Sports Participation</strong></td>
<td>5.73(5.30)</td>
<td>5.53(4.96)</td>
</tr>
<tr>
<td><strong>BOTMP Rank</strong>*</td>
<td>71.55(28.98)</td>
<td>62.39(30.49)</td>
</tr>
<tr>
<td><strong>Social Competence</strong></td>
<td>19.69(3.86)</td>
<td>19.56(3.99)</td>
</tr>
<tr>
<td><strong>College Education (%)</strong></td>
<td>31.93</td>
<td>33.82</td>
</tr>
</tbody>
</table>

*Statistically different between genders (p<.05); £5 males and 4 females did not have a BMI reading; †1 female did not have a recorded age.

Table 2A provides mean organized sport participation values by gender and motor performance quartiles. Table 2B provides mean organized sport participation values by gender and social competence groups. ANOVA tests for motor performance and sport participation on males and females computed F values of 27.51 and 18.18, respectively. All p values were less than the significant levels of 0.05, with comparative differences being based on Bonferroni post-hoc test. In males, significant differences in organized sport participation were in all motor performance comparisons except when comparing 1st and 2nd quartile. In females, organized sport participation had significant differences in all comparisons except when comparing the 2nd motor performance quartile to the 1st and 3rd quartiles. T-tests for social competence and sport participation were performed on males and females with t values being -7.16 and -8.37, respectively. All p values were less than the significance levels of 0.05. Based on visually and statistically comparing the mean organized sport participation measurements between high and low social competence groups, the high social competence group had significantly higher sport participation compared to the low social competence group in both genders.
through literature. It is evident that both males and females are as independent exposures to display previous findings shown performance (quartiles) and social competence (high or low) sets of odds ratios created through logistic regression are motor performance for the model for males, it also remained significant. The first two confounders (age, BMI and SES) were included in the multiple regression models. The addition of social competence reduced confounders. In males, the odds are slightly reduced as the child moves up the motor performance quartiles, with odds being eliminated when males are in the 4th MP quartile with low SC. In females, this relationship is not as clear with the 3rd MP quartile being at greater odds than the 1st and 2nd quartiles for low sport participation. However, these odds ratios are within each other’s confidence intervals after adjusting for confounders.

<table>
<thead>
<tr>
<th>1st Quartile</th>
<th>Males (n=982)</th>
<th>Females (n=976)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Size</td>
<td>193</td>
<td>276</td>
</tr>
<tr>
<td>Mean</td>
<td>3.90</td>
<td>4.25</td>
</tr>
<tr>
<td>2nd Quartile</td>
<td>Males (n=982)</td>
<td>Females (n=976)</td>
</tr>
<tr>
<td>Sample Size</td>
<td>224</td>
<td>274</td>
</tr>
<tr>
<td>Mean</td>
<td>4.67</td>
<td>5.31</td>
</tr>
<tr>
<td>3rd Quartile</td>
<td>Males (n=982)</td>
<td>Females (n=976)</td>
</tr>
<tr>
<td>Sample Size</td>
<td>276</td>
<td>266</td>
</tr>
<tr>
<td>Mean</td>
<td>6.05</td>
<td>5.94</td>
</tr>
<tr>
<td>4th Quartile</td>
<td>Males (n=982)</td>
<td>Females (n=976)</td>
</tr>
<tr>
<td>Sample Size</td>
<td>289</td>
<td>160</td>
</tr>
<tr>
<td>Mean</td>
<td>7.45</td>
<td>7.46</td>
</tr>
</tbody>
</table>

Table 2A: Mean organized sport participation scores by gender and motor performance quartiles.

<table>
<thead>
<tr>
<th>High Social Competence</th>
<th>Males (n=982)</th>
<th>Females (n=976)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Size</td>
<td>561</td>
<td>560</td>
</tr>
<tr>
<td>Mean</td>
<td>6.68*</td>
<td>6.59*</td>
</tr>
<tr>
<td>Low Social Competence</td>
<td>Males (n=982)</td>
<td>Females (n=976)</td>
</tr>
<tr>
<td>Sample Size</td>
<td>421</td>
<td>416</td>
</tr>
<tr>
<td>Mean</td>
<td>4.46</td>
<td>4.11</td>
</tr>
</tbody>
</table>

*significantly higher organized sport participation mean

Table 2B: Mean organized sport participation scores by gender and social competence groups.

Table 3 displays the independent exposure odds ratios for motor performance and social competence by gender. Motor performance and social competence remained significant indicators of participation in organized sports when all confounders (age, BMI and SES) were included in the multiple regression models. The addition of social competence reduced the parameter estimate of motor performance, indicating a more impactful role of social competence on participation in organized sports. When parental education was included in the model for males, it also remained significant. The first two sets of odds ratios created through logistic regression are motor performance (quartiles) and social competence (high or low) as independent exposures to display previous findings shown through literature. It is evident that both males and females are at risk of low participation in organized sports when compared to the 4th motor performance quartile, with this risk remaining after adjusting for confounders. Despite the child’s gender, their risk of low sport participation is reduced as one goes into a higher motor performance quartile. Low social competence was shown to increase the risk of low sport participation when compared to children of the same age, BMI and SES with high social competence.

Table 4 displays the third set of odds ratios with four groups based on motor performance and social competence groups. Table 5 displays the fourth set of odds ratios with further categorized exposure for motor performance and social competence by gender where eight groups were created. The third set of odds ratios further classifies motor performance (MP) into high (3rd and 4th quartiles) and low (1st and 2nd quartiles) groups, with social competence (SC) groups remaining the same and four groups are created with these categories (Low MP/Low SC, Low MP/High SC, High MP/Low SC and High MP/High SC). This will allow for us to view the simplified version of the moderating role of social competence in our key relationship. Children with low MP and low SC, their odds of low sport participation are very high when compared to children with high MP and high SC. The two exposures together, their odds of low sport participation are much greater. However, once either MP or SC is improved to higher levels, the odds of low sport participation are greatly reduced when compared to children with high MP and high SC – a key focus in this investigation. This left odds ratios of 2.132 and 2.999 when SC improved in males and females respectively, and odds ratios of 1.984 and 1.939 when MP was higher in males and females respectively. All odds ratios remained significant (p<.05) when compared to children with high MP and high SC. For the fourth set of odds ratios, motor performance is expanded back to its quartile form and eight groups are further created for this analysis – each quartile is grouped with high SC (4 groups) then with low SC (4 groups), for males and females (reference group=4th MP quartile with high SC). It is clear that for both genders, children in the 1st (lowest) MP quartile with low SC are at the highest odds for low participation in organized sports when compared to the reference group, even after adjusting for confounders. In males, the odds are slightly reduced as the child moves up the motor performance quartiles, with odds being eliminated when males are in the 4th MP quartile with low SC. In females, this relationship is not as clear with the 3rd MP quartile being at greater odds than the 1st and 2nd quartiles for low sport participation. However, these odds ratios are within each other’s confidence intervals after adjusting for confounders.

<table>
<thead>
<tr>
<th>1st Quartile</th>
<th>Males: Unadjusted</th>
<th>Males: Adjusted*</th>
<th>Females: Unadjusted</th>
<th>Females: Adjusted*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Size</td>
<td>3.841 (2.579-5.721)</td>
<td>3.629 (2.077-6.343)</td>
<td>2.950 (1.951-4.463)</td>
<td>3.256 (1.921-5.520)</td>
</tr>
<tr>
<td>2nd Quartile</td>
<td>2.509 (1.735-3.627)</td>
<td>2.395 (1.505-3.810)</td>
<td>2.240 (1.487-3.735)</td>
<td>2.330 (1.394-3.895)</td>
</tr>
<tr>
<td>3rd Quartile</td>
<td>1.857 (1.313-2.627)</td>
<td>1.665 (1.090-2.545)</td>
<td>1.896 (1.256-2.862)</td>
<td>2.466 (1.461-4.162)</td>
</tr>
<tr>
<td>4th Quartile</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Low Social Competence</td>
<td>2.259 (1.727-2.954)</td>
<td>2.203 (1.575-3.082)</td>
<td>2.132 (1.632-2.786)</td>
<td>2.225 (1.588-3.117)</td>
</tr>
<tr>
<td>High Social Competence</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

*adjusted for age, BMI and SES.

Table 3: Odds ratios on low participation in organized sports by independent exposures of motor performance and social competence by gender.
Globally, cardiovascular diseases are the leading cause of death with an estimated 26.3 million annual deaths predicted by 2030.24 Low physical activity and poor physical fitness are significant risk factors for cardiovascular disease among adults.24 In addition, atherosclerotic processes that result in coronary heart disease have their origins during childhood.1 These are cardiovascular risk factors which are amenable to change and the importance of promoting active lifestyles among children is evident. A key concern with being physically active, such as participating in organized sports, is the capacity of a participant to execute skilled movements and not all children demonstrate high levels of motoric competence. However, as sport is a key aspect of a child’s physical activity environment, the opportunity for all to participate is important. It has been repeatedly reported that there is an association between levels of motor performance, including children with DCD, and lower physical activity levels. This activity deficit is persistent over time, sincerely affecting girls more than boys.25 Children with delayed motor development and prior social experiences, and acceptance.28 Another barrier to focus on personal, family-related and peer-related factors including education, communication and occupation.27 Therefore, highlighting the importance of social competence for interventions among school-age children in crucial. Interventions need to focus on personal, family-related and peer-related factors which all impact a different aspect of social competence. Peer-to-peer exchanges are a vital component in the development of social competence, with factors including the context, culture and prior social experiences, and acceptance.29 Another barrier children face in being physically active in organized sports is parental resources.29 Many low income families do not have the financial capacity to support their child with enrollment in, and provide equipment for various extracurricular activities particularly sport teams or clubs. Social competence interventions in school-aged years can be expanded into physical education classes where organized sports are applied. Implementing man-

<table>
<thead>
<tr>
<th></th>
<th>Males: Unadjusted</th>
<th>Males: Adjusted*</th>
<th>Females: Unadjusted</th>
<th>Females: Adjusted*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low MP/Low SC</td>
<td>5.225</td>
<td>4.938</td>
<td>3.572</td>
<td>3.384</td>
</tr>
<tr>
<td>Low MP/High SC</td>
<td>2.143</td>
<td>2.132</td>
<td>2.529</td>
<td>2.999</td>
</tr>
<tr>
<td>(1.507-3.047)</td>
<td>(1.395-3.259)</td>
<td>(1.672-3.823)</td>
<td>(1.763-5.103)</td>
<td></td>
</tr>
<tr>
<td>High MP/Low SC</td>
<td>2.061</td>
<td>1.984</td>
<td>1.942</td>
<td>1.939</td>
</tr>
<tr>
<td>(1.447-2.937)</td>
<td>(1.249-3.150)</td>
<td>(1.385-2.724)</td>
<td>(1.263-2.976)</td>
<td></td>
</tr>
<tr>
<td>High MP/High SC</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

*adjusted for age, BMI and SES.

Table 4: Odds ratios on low participation in organized sports by dichotomized motor performance with social competence by gender.

<table>
<thead>
<tr>
<th></th>
<th>Males: Unadjusted</th>
<th>Males: Adjusted*</th>
<th>Females: Unadjusted</th>
<th>Females: Adjusted*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st MP/High SC</td>
<td>7.129</td>
<td>6.723</td>
<td>5.364</td>
<td>6.200</td>
</tr>
<tr>
<td>2nd MP/Low SC</td>
<td>6.084</td>
<td>4.730</td>
<td>4.219</td>
<td>5.721</td>
</tr>
<tr>
<td>3rd MP/Low SC</td>
<td>4.066</td>
<td>3.713</td>
<td>5.396</td>
<td>8.378</td>
</tr>
<tr>
<td>4th MP/Low SC</td>
<td>1.716</td>
<td>1.418</td>
<td>1.865</td>
<td>2.888</td>
</tr>
<tr>
<td>(1.027-2.868)</td>
<td>(0.765-2.628)</td>
<td>(0.956-3.637)</td>
<td>(1.237-6.742)</td>
<td></td>
</tr>
<tr>
<td>1st MP/High SC</td>
<td>3.808</td>
<td>3.014</td>
<td>3.085</td>
<td>4.450</td>
</tr>
<tr>
<td>(2.226-6.514)</td>
<td>(1.426-6.371)</td>
<td>(1.779-5.352)</td>
<td>(2.218-8.930)</td>
<td></td>
</tr>
<tr>
<td>2nd MP/High SC</td>
<td>1.956</td>
<td>1.908</td>
<td>2.240</td>
<td>2.602</td>
</tr>
<tr>
<td>(1.205-3.173)</td>
<td>(1.049-3.471)</td>
<td>(1.311-3.830)</td>
<td>(1.313-5.154)</td>
<td></td>
</tr>
<tr>
<td>3rd MP/High SC</td>
<td>1.603</td>
<td>1.222</td>
<td>1.556</td>
<td>2.400</td>
</tr>
<tr>
<td>(1.035-2.482)</td>
<td>(0.707-2.112)</td>
<td>(0.926-2.615)</td>
<td>(1.227-4.693)</td>
<td></td>
</tr>
<tr>
<td>4th MP/High SC</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

*adjusted for age, BMI and SES.

Table 5: Odds ratios on low participation in organized sports by motor performance quartiles with social competence by gender.

DISCUSSION

Self-efficacy, a component of social competence, has been recognized as one’s ability to overcome barriers of physical activity, perceptions of physical competence, positive attitudes towards physical education, enjoyment of physical activity and parent/peer support as positive factors associated with higher physical activity in young children.26 In order to develop and maintain a positive support system, one must have a relatively high social competence. Social competence is recognized as a ‘central organized construct of development’ in many aspects including education, communication and occupation.27 Therefore, highlighting the importance of social competence for interventions among school-age children in crucial. Interventions need to focus on personal, family-related and peer-related factors which all impact a different aspect of social competence. Peer-to-peer exchanges are a vital component in the development of social competence, with factors including the context, culture and prior social experiences, and acceptance.29 Another barrier children face in being physically active in organized sports is parental resources.29 Many low income families do not have the financial capacity to support their child with enrollment in, and provide equipment for various extracurricular activities particularly sport teams or clubs. Social competence interventions in school-aged years can be expanded into physical education classes where organized sports are applied. Implementing man-
Sociability, that is, the ability to improve their social competence through the use of
educational curricula, such as sports participation, is important. Males who are more physically active with peers are more socially accepted in the classroom, positively affecting their perceived social competence. However, both sexes are able to improve their social competence through involvement in social activities, friendships, and group interactions. Children with poor motor performance, including children with DCD, have difficulties with attention, language, short-term memory, social skills, and academic performance. In environments where high levels of physical skills are valued, children with DCD are socially isolated by peers, diminishing the opportunities to develop their social competence. As a consequence, children with poor motoric consequences may be doubly impaired—both motorically and socially—in their capacity to participate in physical activity and particularly in organized sports.

The results make it evident that social competence plays a significant role both by itself in relation to involvement in sport and in the relationship between motor performance and sport participation. The ANOVA and t-test results demonstrate that children with higher motor performance and higher social competence have greater participation in organized sports. Multiple regression models provided evidence that motor performance and social competence are independent contributors to sport participation for both sexes, with social competence having a greater moderating effect in females (17%) than males (9%). This is likely due to the fact that motor performance is a more prominent factor for sport participation in males, leaving less room for amelioration from social competence due to poor motor performance’s profound effect on performance. Parental education plays a strong role in regard to sport participation, especially in males. This can be related to the cost of extracurricular activities borne by the parents as well as their drive to promote a healthy lifestyle. Children with poor motor competence from lower SES groupings appear doubly burdened, limiting their opportunities to play organized sports. As previously described, this variable includes school teams, where coaches determine who is on the team, despite the child’s desire to participate.

Odds ratio analysis demonstrates that having greater social competence reduces the odds of low sport participation in children (particularly girls) with lower motor performance, although it does not fully eliminate the risk. The majority of the final set of odds ratios remained significant after adjusting for known confounders, supporting the influential role that social competence has on sport participation.

There has been little research on the association between social competence and sport participation in children, and none which considers the effect on those with motor impairments. The results reported here suggest that providing children with motor limitations a supportive social network could facilitate regular involvement in physical activity. Having the opportunity to engage with more active friends and family members, will increase the likelihood that children will adopt healthy lifestyle choices, including physical activity participation. It is important to recognize the dissimilar social norms of males and females for sport participation. Girls have a wider range of activities in which to view themselves as socially competent such as the dramatic arts or singing. However, the social expectations for boys are more focused within the physical activity spectrum. Boys who make the school’s team and participate in intramural sports are more socially accepted by both peers and significant others thus aiding in the development of their social competence. The differential effect of social competence among genders was shown in the odds ratios where social competence had a greater impact on male participation in sports.

We acknowledge that there are limitations to this study which preclude drawing any conclusions regarding causation. Both sports participation and social competence were self-reported although both were assessed using well-established measures. Sexual maturity was not evaluated however within the age group reported the large majority of the participants in the PHAST study were in Tanner Stage 2.

CONCLUSION

Lower social competence is an indication of lower social skills and interactions between peers. It is important for Public Health to recognize the essential role that social competence plays at a young age in the adoption of healthy lifestyles. Higher social competence provides children with a necessary skill to heighten engagement in organized sports across all motor performance levels, emphasizing the role that social competence plays in physical activity participation and healthy active living, regardless of motor performance. Due to the social norms placed on young boys to participate in physical activities, the particular importance of social competence for participation in organized sports for young boys and among those with motor impairments should be recognized when designing and implementing activity promotion strategies for youth.

CONFLICTS OF INTEREST

There is no conflicts of interest in this report as funding was from CIHR and there is no financial benefit accruing to any of the author’s.

CONSENT

The patients of this study have provided written permission for publication of the case details.

REFERENCES


The Threshold of Physical Fitness in terms of Maximum Oxygen Uptake as a Predictive Factor for Achieving Prosthetic Walking in Elderly with Unilateral Trans-femoral Amputation or Hip Disarticulation

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ABSTRACT

The aim of this study was to determine the threshold of physical fitness level in terms of maximum oxygen uptake as an important predictive factor for achieving prosthetic walking in elderly with unilateral trans-femoral amputation or hip disarticulation. Subjects were 69 amputees aged 60 and above. Mean age was 67.3±5.5 years (Range 60-81 years). All of them were hospitalized at our Center for prosthetic walking training and who had never been fitted with prosthesis before. The incremental exercise test was performed to evaluate physical fitness before they began prosthetic rehabilitation. After completion of the rehabilitation program, they were asked to walk at comfortable walking speed to evaluate their prosthetic ambulation ability. Subjects who could walk at least 100 meters without ambulatory aids or with only one cane were classified as successful prosthetic users. All others were classified as failed prosthetic users. There were 47 amputees in success group and 22 in failure. Other clinical information about each patient before fitting prosthesis was collected retrospectively from their charts. Significant difference was observed between the groups in cause of amputation, the number of comorbidities, ability to stand on the non-amputated leg, and physical fitness. Logistic regression analysis showed that maximum oxygen uptake as a proportion of predicted maximum oxygen uptake (%VO2max) was found to be significantly related to successful prosthetic walking. The ROC analysis showed that the threshold of %VO2max was 53.9, its sensitivity was 79% and specificity was 92%. Our results showed the prognosis of prosthetic rehabilitation in elderly amputees on the basis of physical fitness. Incorporating other predictive factors with the findings of this study is essential to increase predictability.

KEYWORDS: Elderly; Amputation; Trans-femoral; Hip disarticulation; Physical fitness; Oxygen uptake; Threshold; Prosthesis; Rehabilitation; Unilateral.

ABBREVIATIONS: DM: Diabetes Mellitus; PAD: Peripheral Arterial Disease; CLI: Critical Limb Ischemia; VO2: Oxygen uptake; VO2max: Maximum oxygen uptake; %VO2max: Maximum oxygen uptake during exercise as a proportion of predicted maximum oxygen uptake; TF: Trans-femoral; TT: Trans-tibial; HD: Hip Disarticulation; OR: Odds Ratio; CI: Confidence Interval; ROC: Receiver Operating Characteristic.
INTRODUCTION

Due to the increasing prevalence of Diabetes Mellitus (DM) and an increase in the elderly population, there has been an increase in cases of Peripheral Arterial Disease (PAD). It is important to note that the biggest cause of lower-limb amputations in the elderly population is PAD.13 Despite the current progress in revascularization procedures for Critical Limb Ischemia (CLI), more than 100,000 major amputations are performed annually in the US.45

In recent years, due to increased recognition of the functional advantages of preservation of the knee joint and advances in revascularization procedures, many surgeons recognize the benefits of preservation of the knee joint when performing amputation surgery. As a result, the ratio of Trans-femoral (TF) to Trans-tibial (TT) amputation has decreased over the years.2,6-8 However, patients with higher level lower limb amputations resulting not only from vascular disease but also from tumor and trauma exist. Because of the increase in the elderly population, most patients have multiple comorbidities and rehabilitation is not always easy.

It has been reported that the rehabilitation success rate for elderly lower limb amputees is 66-76% for TT and 46-53% for TF amputees.9,14 However, the rehabilitation success rate for patients with PAD is lower than the generally reported success rates. It has been reported that rehabilitation success rates are only 34%-47% for TT amputees and 9-20% for TF amputees.12-14 Thus, many older patients may not be considered successful prosthetic rehabilitation candidates. Furthermore, it is not easy to predict the outcomes of these patients, to decide the indication for prosthetic rehabilitation even for experienced clinicians.15 If predictions of successful prosthetic rehabilitation could be made more accurately in older patients with higher level lower limb amputations before commencing rehabilitation, it would greatly help to delineate an efficient multidisciplinary rehabilitation approach with clearer rehabilitation goals.

Several predictive factors affecting successful prosthetic rehabilitation have been described in previous research. However, most previous research studied subjects with various amputation levels and wide age ranges, from young to elderly patients. Furthermore, as indicated by Moore,16 despite the increased energy consumption required for prosthetic walking the higher the level of amputation, previous research has not included an evaluation of the physical fitness of amputees. Thus, this previous research may not be enough to clinically determine rehabilitation goals. In this study, subjects were limited to unilateral trans-femoral and hip disarticulation amputees aged 60 years or above who entered our center with no previous prosthetic rehabilitation history. The physical fitness of amputees was evaluated using an exercise load test. The aim of this study was to determine the threshold of physical fitness level in terms of maximum oxygen uptake as a predictive factor for achieving prosthetic walking in elderly with unilateral trans-femoral amputation or hip disarticulation.

MATERIALS AND METHODS

Subjects

The patients were 69 unilateral lower limb (trans-femoral amputation or hip disarticulation) amputees (44 men and 25 women) who were hospitalized at Hyogo Rehabilitation Center (Kobe Japan) for prosthetic walking training and who had never been fitted with prosthesis before. All of them were referred to our center for prosthetic rehabilitation. Their age was 67.3±5.5 years (Mean±SD, Range 60-81 years). The cause of amputation was PAD in 25 cases and non-PAD in 44 cases. The amputation level was TF in 58 patients and Hip Disarticulation (HD) in 11 patients. None of the patients had any Steinberg factors11 impeding prosthetic walking such as mental deterioration, advanced neurological disorders, congestive cardiac failure, advanced obstructive pulmonary disease, or advanced hip flexion contracture. The patients were informed of the purpose of this study and the associated risks, and verbal and written consent was obtained. The study protocol and methods were approved by the Institutional Review Board of Hyogo Rehabilitation Center (Kobe Japan).

Rehabilitation Program

The rehabilitation program was identical for all patients. Training programs for walking with prosthesis emphasize acclimatization to the use of a prosthesis, bearing an adequate amount of body weight on the prosthesis, and the correction of abnormal walking patterns. Once amputees can overcome these problems and achieve a walking speed within a certain range that suited them, their training was completed. This program emphasizes on endurance, and aimed at achieving prosthetic walking with any necessary ambulatory aids (cane, crutch, or walker) at amputees most comfortable walking speed.

Evaluation of Prosthetic Ambulation Ability

After completion of the rehabilitation program, patients were permitted to use any necessary ambulatory aids and asked to walk at their most comfortable walking speed on a level surface. Patients who could walk at least 100 meters without ambulatory aids or with only one cane were classified as successful prosthetic users. All others were classified as failed prosthetic users.

Investigation of Clinical Information

Information about each patient before fitting prosthesis was collected retrospectively from clinical charts made during admission. This information included cause of amputation (PAD or non-PAD), number of co-morbidities, and ability to stand on the non-amputated leg (possible or impossible). Co-morbidities were common in these patients, and included the presence of...
hypertension, DM, end-stage renal disease, hepatic disorders, cerebral vascular disturbance, ischemic heart disease, degenerative joint disease, visual disorder, endocrine disease, malignant disorder such as metastasis, and inflammatory disease such as chronic osteomyelitis. Standing was assessed as possible if patients could stand either unsupported or supported by one hand on a desk.

Evaluation of Physical Fitness

Lower limb amputees performed one-leg cycling tests with the non-amputated leg. This test was conducted before the patients began prosthetic rehabilitation. The details of this method have already been reported. A cycle ergometer (Lode Angio WLP-300ST, Holland, Netherlands) that can be manipulated in a supine position was used.

The test was conducted with the patients seated with their upper bodies reclining at an angle of approximately 45 degrees. This incremental exercise test was begun with 3 minutes of unloaded pedalling, followed by increments of 5–15 W/min, until the patient’s self-assessed maximum load. The test patients were directed to turn the pedals 60 times per minute. Each patient operated the ergometer with his or her non-amputated leg. During exercise, respiratory gas was monitored with a respiromonitor (Minato RM-300 system, Osaka, Japan), and cuff blood pressure was determined every minute with an autoelectrocardiometer (STPB-780, Colin, Komaki, Japan).

The maximum oxygen uptake (ml/kg per minute) during exercise, as a proportion of the predicted maximum oxygen uptake (%VO2max; ml/kg per minute) was used as an indicator of physical fitness.

STATISTICAL ANALYSIS

Continuous variables (Age and %VO2max) were compared using t-tests, and categorical variables (sex, cause of amputation, number of comorbidity, level of amputation and ability to stand on non-amputated leg) using chi-squared tests to determine which variables differed significantly between the success and failure groups. The variables that achieved statistical significance in t-tests or chi-squared tests at the 0.05 level were then included in multivariate logistic regression analysis. Pearson correlation co-efficients were calculated to determine the strength of the relationship between variables. The model was simplified in a stepwise fashion by removing variables with a P value greater than 0.05. Odds Ratio (OR) and 95% Confidence Interval (CI) were calculated for successful walking with prosthetics associated with independent variables. Model fit was tested with Hosmer-Lemeshow statistics. Sensitivity and specificity in predicting successful walking status were calculated. Sensitivity was defined as the percentage of the success group who were correctly identified. Specificity was defined as the percentage of the failure group who were correctly identified. The ability to predict the outcome of successful walking was assessed by the area under the Receiver Operating Characteristic (ROC) curve.

Statistical evaluation of the data was carried out using the SPSS® statistical package (SPSS Inc., Chicago, IL, USA) for Windows®.

RESULTS

In the prosthetic ambulation ability evaluation, there were 47 amputees in the success group (30 men and 17 women) aged 66.6±5.3 years, 10 were HD amputees. There were 22 amputees in the failure group (14 men and 8 women) aged 68.8±6.0 years, 1 was a HD amputee. In the failure group, 5 amputees could walk more or less than 100 m with two canes, 10 could walk with crutch, 1 with walker, and 6 could not walk at all and used wheelchair. There was a significant difference between the two groups in cause of amputation, number of co-morbidities, ability to stand on the non-amputated leg, and %VO2max (p<0.05). No significant difference was observed between the two groups in age, sex and the level of amputation (Table 1).

<table>
<thead>
<tr>
<th>Cause of amputation (PAD/Non-PAD)</th>
<th>success group</th>
<th>failure group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (male/female)</td>
<td>n=47</td>
<td>n=22</td>
</tr>
<tr>
<td>Age[6]</td>
<td>66.6±5.3</td>
<td>68.8±6.0</td>
</tr>
<tr>
<td>%VO2max</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level of amputation (TF/HD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ability to stand on non-amputated leg (Possible/Impossible)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>%VO2max</td>
<td>64.7±14.2</td>
<td>44.7±9.3</td>
</tr>
</tbody>
</table>

Table 1: Results of success group and failure group

a) Mean±SD  b) Non-paired t-test  c) x2; chi-squared test
TF: Trans-femoral, HD: Hip Disarticulation
PAD: peripheral arterial disease

Significant difference was observed between the two groups in cause of amputation, number of co-morbidities, ability to stand on the non-amputated leg, and %VO2max (physical fitness). No significant difference was observed between the two groups in age, sex and the level of amputation.

Citation:

DOI: 10.17140/SEMOJ-1-120

diction was 79% and specificity was 92% (Hosmer-Lemeshow goodness of fit test, p=0.93).

DISCUSSION

A number of researchers have identified cause of amputation, number of coexisting factors, ability to stand on one leg, and physical fitness as important factors related to successful prosthetic rehabilitation. Our results were in agreement with previous reports in many respects. Based on the logistic regression analysis applied in this study, %VO$_{2\text{max}}$ as an indicator of physical fitness was found to be significantly related to successful walking. Various experts have indicated that physical fitness adequate to meet the energy consumption demands of prosthetic walking is important for geriatric lower limb amputees to regain practical prosthetic walking ability. Furthermore, Moore and Steinberg have stated the importance of evaluating the physical strength of amputees before they begin rehabilitation. However, these researchers have not discussed the level of physical fitness required for successful prosthetic rehabilitation.

Table 2: Stepwise logistic models for predicting successful prosthetic walking.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>OR</th>
<th>95% CI</th>
<th>p value</th>
</tr>
</thead>
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<tr>
<td>Cause of amputation (PAD/Non-PAD)</td>
<td>0.59</td>
<td>0.12-2.95</td>
<td>0.521</td>
</tr>
<tr>
<td>No. of comorbidity (≤1/2/3)</td>
<td>0.52</td>
<td>0.14-1.90</td>
<td>0.321</td>
</tr>
<tr>
<td>Ability to stand on Non-amputated leg</td>
<td>5.48</td>
<td>0.73-41.38</td>
<td>0.099</td>
</tr>
<tr>
<td>%VO$_{2\text{max}}$</td>
<td>1.13</td>
<td>1.05-1.22</td>
<td>0.002</td>
</tr>
<tr>
<td>Hosmer-Lemeshow test</td>
<td>$\chi^2$=3.02</td>
<td></td>
<td>0.93</td>
</tr>
</tbody>
</table>

OR: Odds Ratio.
95% CI: 95% Confidence Interval.
Logistic regression analysis showed that %VO$_{2\text{max}}$ (physical fitness) was significantly related to successful prosthetic walking.

ROC analysis showed that 53.9 were the threshold score of %VO$_{2\text{max}}$ for distinguish success group from failure group, and its sensitivity was 79%, and specificity 92%.

Figure 1: ROC analysis for %VO$_{2\text{max}}$.
Morey examined the relationship between directly measured peak oxygen uptake and self-reported physical functioning in older adults aged 65-90 years old, and reported that individuals with the oxygen uptake lower than 18.3 ml/kg/min had significant difficulty in the performance of daily tasks. Bruce proposed an assessment method to predict maximum oxygen uptake (VO₂max) from an individual’s age. According to his report, the predicted VO₂max of active older men aged 60-70 years old can be expressed as 33 and 27 ml/kg/min, and active older women aged 60-70 years as 24 and 20 ml/kg/min, respectively. Therefore, 53.9% VO₂max was within 18.3 ml/kg/min, that was detected as a minimum guideline for older adults to be able to perform daily tasks. According to Posner, around 60% VO₂max represents an exercise intensity approximately equal to the anaerobic threshold value for people in their 50-70 s. Kuribayash conducted exercise load tests on lower limb amputees using arm ergometry and reported that the movement capabilities depend to a large extend on the physical fitness of the subjects, and 40-60% VO₂max was the acceptable exercise intensity that lower limb amputees could bear. Therefore, our value of 53.9% VO₂max seemed not to be an excessive exercise intensity.

In this study, we classified the patients who could walk at least 100 meters without ambulatory aids or with only one cane as successful prosthetic users. Because there is no standard definition for successful prosthetic rehabilitation, and we considered that prosthetic users who could walk at least 100 meters had sufficient ability for prosthetic ambulation in their community. Actually, in the success group, 39 of 47 patients (82.9%) could keep their walking ability with prosthesis at 6 month after discharge from our center. On the contrary, in the failure group, only 4 of 22(18.2%) patients could walk with two canes or crutch after discharge. Therefore, our classification seems to be appropriate.

As to prescription of prosthesis, type of suspension was Canadian socket for all hip disarticulation amputees, and suction socket for all Trans-femoral amputees. Knee mechanisms were as follows; 47 success group amputees, 19 were prescribed single axis knee joint, 19 polycentric knee joint, 9 fixed knee joint, and 22 failure group amputees, 7 were single axis knee joint, 7 polycentric knee joint, 8 fixed knee joint, respectively. At 6 month follow up after discharge, 39 success group amputees who could keep their walking ability, 16 were single axis (dropout rate 15.8%), 17 polycentric (10.6%), 6 fixed (33.2%), and 4 failure group amputees who could keep their walking ability, 1 were single axis (dropout rate 85.8%), 1 polycentric (85.8%), 2 fixed (75.0%), respectively. We found no relationship between the type of prosthesis and the outcome of 6 month follow up.

The limitation of this research is the necessity of expensive and special apparatus, and thus measurement of physical fitness cannot be easily and routinely performed. Since independence in activities of daily living has been significantly associated with walking ability after rehabilitation with a prosthesis, and 53.9% VO₂max is the value within the range of minimum guideline for the older adult to perform daily tasks, when the apparatus is not clinically available, assessing whether an amputee is independent in performing daily tasks using a wheelchair before commencing prosthetic rehabilitation might be an alternative method to estimate physical fitness. If an amputee is found not to be independent, there might be a great possibility that he will not be a candidate for successful prosthetic rehabilitation.

CONCLUSION

In summary, this study showed that by using an optimal cut-off value of 53.9% VO₂max, the predictability for achieving sufficient prosthetic walking ability on the basis of physical fitness was quite high. However, clinical judgment from the perspective of physical fitness alone is insufficient. Incorporating other predictive factors with the findings of this study is essential for increasing predictive accuracy.

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AUTHOR’S CONTRIBUTIONS

Study concept and design: T. Chin.
Acquisition of data: T. Chin, H. Kohno and M. Toda.
Analysis and interpretation of data: N. Maeda and M. Toda.
Drafting manuscript: M. Toda and T. Chin.
Critical revision of manuscript: A. Kitagawa.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest regarding the publication of this paper.

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