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GUILHERME RIBEIRO BRANCO

FATORES MUSCULOESQUELÉTICOS E DE POSICIONAMENTO SOBRE A BICICLETA ASSOCIADOS À OCORRÊNCIA DE DOR ANTERIOR NO JOELHO EM CICLISTAS DE MOUNTAIN BIKE

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Dissertação apresentada ao Programa de Pós-Graduação em Reabilitação e Desempenho Funcional da Universidade Federal dos Vales do Jequitinhonha e Mucuri, como requisito parcial para obtenção do título de mestre.

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GUILHERME RIBEIRO BRANCO

Fatores musculoesqueléticos e de posicionamento sobre a bicicleta associados à ocorrência de dor anterior no joelho em ciclistas de mountain bike

Dissertação apresentada ao MESTRADO EM REABILITAÇÃO E DESEMPENHO FUNCIONAL, nível de MESTRADO como parte dos requisitos para obtenção do título de MAGISTER SCIENTIAE EM REABILITAÇÃO E DESEMPENHO FUNCIONAL.

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Diamantina

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RESUMO

As lesões atraumáticas no ciclismo podem ser altamente prevalentes, estando a dor anterior no joelho dentre as mais expressivas e a que proporciona maior impacto funcional. Para tal lesão, sugere-se que variáveis musculoesqueléticas e de posicionamento do ciclista sobre a bicicleta possam ser fatores associados. No entanto, a literatura é bastante escassa no que tange à descrição, à análise e a interação entre essas variáveis associadas à ocorrência de dor anterior no joelho em ciclistas de *mountain bike*. O objetivo da presente dissertação foi investigar a associação entre fatores musculoesqueléticos e de posicionamento sobre a bicicleta com a ocorrência de dor anterior no joelho em ciclistas de *mountain bike*. Um primeiro estudo foi planejado para verificar a associação entre as variáveis cinemáticas do ciclista ao pedalar com a ocorrência de dor anterior no joelho em ciclistas de *mountain bike* por meio de regressão logística. Flexão plantar, flexão e extensão de joelho e inclinação de tronco foram identificados como preditores significativos de dor anterior no joelho nesta população. Um segundo estudo foi desenvolvido para investigar as interações entre fatores musculoesqueléticos relacionados ao tronco, ao quadril e ao complexo tornozelo-pé associadas com a ocorrência de dor anterior no joelho em *mountain bikers* por meio da análise da CART. Interações entre amplitude de movimento passiva de rotação medial do quadril, força da musculatura póstero-lateral do quadril, amplitude de movimento de dorsiflexão do tornozelo e alinhamento perna-antepé identificaram *mountain bikers* com e sem dor anterior no joelho. Os resultados da presente dissertação revelaram a participação de fatores musculoesqueléticos e de posicionamento do ciclista sobre a bicicleta relacionados à dor anterior no joelho em ciclistas de *mountain bike*.

Descritores: Joelho. Lesão. Bike fit. Esporte.

ABSTRACT

Non-traumatic injuries in cycling can be highly prevalent, among which anterior knee pain is the most common (36%) and the one which causes the highest functional impact. It is suggested that musculoskeletal variables and cyclist dynamic positioning on the bike may be associated to this condition. However, literature is quite scarce in terms of description, analysis and interaction among those aspects relative to anterior knee pain occurrence in mountain bike cyclists. The aim of the present master thesis was to investigate the association among musculoskeletal factors and dynamic bike positioning with anterior knee pain occurrence in mountain bike cyclists. Two studies were then planned. The first one was arranged to verify associations among cyclist's kinematic variables during pedaling with anterior knee pain occurrence in mountain bike cyclists by means of logistic regression. Plantarflexion, knee flexion and extension, and trunk inclination were identified as significative predictors of anterior knee pain in this population. A second study was developed to investigate possible interactions among musculoskeletal factors related to trunk, hip and ankle-foot associated to anterior knee pain occurrence in mountain bikers by means of CART analysis. Interactions among passive hip internal rotation range of motion, posterolateral hip muscle strength, ankle dorsiflexion range of motion and shank-forefoot alignment were able to identify mountain bikers with and without anterior knee pain. The results of the present master thesis revealed participation of musculoskeletal and dynamic body positioning on the bike related to anterior knee pain in mountain bikers.

Keywords: Knee. Injury. Bike fit. Sports.

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1. INTRODUÇÃO

O uso da bicicleta ao redor do mundo é bastante popularizado, atuando em papéis importantes como meio de transporte, recreação, atividade desportiva amadora ou competitiva, treinamento físico e até mesmo reabilitação (DETTORI, NORVEL, 2006; GALVÃO et al., 2013). O Brasil é o terceiro produtor mundial de bicicletas, detendo a quinta frota do planeta (BRASIL, 2007). Dados da Associação Brasileira de Fabricantes de Motocicletas, Ciclomotores, Motonetas, Bicicletas e Similares (Abraciclo) revelam um aumento acumulado da produção de bicicletas em cerca de 10% de 2017 para 2018 (ABRACICLO, 2018), o que sugere o crescimento do número de seus usuários. Assim, diante da possibilidade da ocorrência de lesões inerentemente relacionadas ao esporte, (van MECHELEN, HLOBIL, KEMPER, 1992), especula-se que, com o aumento da prática do ciclismo, haja uma maior demanda em termos de assistência de saúde por seus praticantes. Desse modo, os profissionais de saúde que lidam diretamente com esportes deverão estar mais capacitados para a abordagem das particularidades vivenciadas pelos ciclistas, especialmente no que se refere ao tratamento e, em especial, à prevenção das lesões traumáticas e atraumáticas (MELLION, 1991).

Apesar dos números expressivos relacionados às lesões traumáticas em ciclistas, de modo geral, estas podem ser reduzidas ou prevenidas pelo uso de equipamentos de segurança adequados e mantendo a bicicleta em excelentes condições mecânicas. Além disso, adoção de direção defensiva e da prática em ambientes específicos (como ciclovias) e com boas condições de manutenção e de projeção da pista também foram identificadas como estratégias bem-sucedidas na redução destas lesões (DETTORI, NORVEL, 2006; MELLION, 1991). Já no que diz respeito às lesões atraumáticas (*overuse*), estas podem acometer 85% dos ciclistas no período de um ano (WILBER et al., 1995), figurando a dor anterior no joelho (DAJ) dentre as lesões mais prevalentes em ciclistas profissionais de estrada, com taxa anual de 36%. Além disso, tal lesão também compõe o grupo daquelas que mais frequentemente levou os ciclistas a procurar assistência de saúde, tendo sido a lesão que mais afastou estes atletas de treinamentos ou de competições (CLARSEN et al., 2010).

O *mountain bike* é uma modalidade do ciclismo reconhecida pela Union Cyclist Internacionale (UCI), associação internacional das federações nacionais de ciclismo que regulamenta este esporte, suas categorias e modalidades. Desde seu surgimento na década de 1970, vem atraindo praticantes e atletas de inúmeras faixas etárias (SABETI-ASCHRAF, et al., 2010) e se tornou bastante popular mundialmente, o que pode ser evidenciado por meio da sua inclusão como esporte olímpico em 1996 (DINGERKUS et al., 1998; KRONISCH, PFEIFFER, 2002). Nesta modalidade, similarmente aos dados obtidos de ciclistas de estrada e de *mountain bike* considerados em conjunto citados anteriormente (WILBER et al., 1995), a prevalência de lesões por *overuse* é também bastante alta, podendo atingir 62% de seus praticantes (LEBEC, COOK, BAUMGARTEL, 2014). Mais uma vez, o joelho se mostra como uma das regiões mais comumente afetadas por este tipo de lesão (LEBEC, COOK, BAUMGARTEL, 2014; SABETI-ASCHRAF, et al., 2010).

Apesar de ser a condição que mais comumente afeta o joelho de ciclistas (CLARSEN et al., 2010; DETTORI, NORVEL, 2006; WANICH et al., 2007), as causas da DAJ ainda não puderam ser estabelecidas para estes atletas (WANICH et al., 2007; JOHNSTON et al., 2017). No entanto, há uma hipótese para esta condição na população em geral, a qual se baseia no modelo patomecânico. Neste modelo, a DAJ se associa à sobrecarga anormal articular, de modo que o estresse anormal possa afetar várias estruturas potencialmente contribuintes para a nocicepção, como osso subcondral, coxim gorduroso infrapatelar, retináculo e estruturas ligamentares, por exemplo. Não obstante, as fontes teciduais específicas relacionadas à DAJ ainda não são conhecidas. Considera-se, então, que a etiologia dessa condição seja uma associação complexa entre diversas influências anatômicas, biomecânicas, psicológicas, sociais e comportamentais. Todavia, a interação entre estes fatores de risco propostos e a entidade clínica de DAJ ainda permanece pouco clara. (POWERS et al., 2017).

Os possíveis fatores relacionados às lesões no ciclismo se integram àqueles inerentes ao ciclista, como capacidade física e alinhamento anatômico, bem como aos associados ao equipamento utilizado, à técnica de pilotagem e de pedalada e ao treinamento (WANICH et al., 2007). Assim, sugere-se que o posicionamento do ciclista proporcionado por seu equipamento possa ser uma das possíveis causas para lesões por sobrecarga, incluindo a DAJ (COHEN, 1993; DANNEMBERG et al., 1996; DETTORI, NORVEL, 2006; TOMPSON et al., 1996; GREGOR, WHEELER, 1994; HOLMES, 1994; MELLION 1991; SABETI-ASCHRAF, et al., 2010), já que mudanças deste posicionamento podem ter efeitos sobre as forças de cisalhamento tibiofemorais, as forças compressivas patelofemorais e os momentos articulares do joelho (BINNI, HUME, 2014; ERICSON, NISSEL, 1986). Ainda, o alinhamento do ciclista sobre a bicicleta pode afetar a cinemática do joelho no plano sagital, especialmente no que diz respeito à amplitude de movimento (ADM) de flexão (BINNI, HUME, 2014; BINNI et al., 2013; TAMBORINDEGUY, HUME, 2011), e, classicamente, sugere-se que a maior flexão de joelho pode predispor o ciclista à DAJ (DICKSON 1985; MELLION, 1991). Desse modo, grande parte das estratégias intervencionistas e preventivas para este grupo de lesões no ciclismo se baseia na otimização do posicionamento corporal do atleta sobre sua bicicleta (BINI, CARPES, 2014). Entretanto, até o momento, há poucas evidências que suportem tais afirmações e a descrição e a análise de dados cinemáticos associados à ocorrência de DAJ na literatura são bastante escassos (JOHNSTON et al., 2017).

Ciclistas com histórico de DAJ exibem movimentação alterada do joelho no plano frontal, com medialização do mesmo em relação ao tornozelo especialmente durante a fase propulsiva da pedalada (quando o joelho se move da flexão à extensão) (BAILEY, MAILLARDET, MESSENGER, 2003). Este movimento excessivo já foi identificado como um contribuinte para DAJ em outras populações (AGEBERG et al., 2010; POWERS, 2010) e pode aumentar o risco de lesão no joelho pelo aumento de cargas aplicadas sobre esta articulação (ABT et al., 2007). O aumento da movimentação do joelho no plano frontal em ciclistas com DAJ foi ligado a alterações na estabilidade central (ABT et al., 2007). Ainda, aumento de rotação interna ou de adução do quadril também foi observado em associação com esta movimentação aumentada durante agachamentos unipodais em descarga de peso em indivíduos assintomáticos (CLAIBORNE et al., 2006) e naqueles com dor patelofemoral (WILLSON, DAVIS, 2008). Este padrão de movimento pode ocorrer em decorrência de resistência passiva reduzida (rigidez) do quadril (SIGWARD, OTA, POWERS, 2008) e fraqueza dos músculos abdutores e rotadores externos do quadril (WILLY, DAVIS, 2011; HEINERT et al., 2008; LEETUN et al., 2004). Além disso, devido ao acoplamento existente entre eversão do retropé e rotação interna do membro inferior (ALMEIDA et al., 2016), a pronação do pé pode também levar à rotação interna do membro inferior (SOUZA et al, 2009). Uma vez que pronação excessiva foi associada à presença de varismo do pé (SOUZA et al., 2009; MENDONCA et al., 2005), o alinhamento do complexo tornozelo-pé pode também estar relacionado à movimentação excessiva do joelho no plano frontal (FONSECA et al., 2011; MCCLAY, MANAL, 1998). Outro fator contribuinte à intensificação de carga na articulação do joelho é a restrição de dorsiflexão do tornozelo, a qual aumentou o risco para DAJ (BACKMAN, DANIELSON, 2011; MALLIARAS, COOK, KENT, 2006). Assim, diante da possível capacidade reduzida de absorção de energia no tornozelo possivelmente relacionada à restrição de ADM de dorsiflexão, aumento de carga na articulação do joelho pode emergir como um mecanismo compensatório. Em suma, a presença de alteração na estabilidade central, fraqueza de abdutores e rotadores externos de quadril, redução da rigidez passiva de rotação interna da articulação do quadril, comprometimento na ADM da articulação do tornozelo e alinhamento anatômico do complexo tornozelo-pé podem influenciar os padrões de movimento do membro inferior e, consequentemente, alterar a distribuição de força nas estruturas articulares do joelho (BITTENCOURT et al., 2012; DE VRIES et al., 2014; DIERKS et al., 2008; LEE, MORRIS, CSINTALAN, 2003; MENDONÇA et al., 2015; SCATTONE et al., 2016; VAN DER WORP et al., 2011). Desse modo, além dos aspectos relacionados ao posicionamento do ciclista sobre a bicicleta, aqueles inerentes às suas capacidades físicas (especialmente no que diz respeito aos fatores musculoesqueléticos) também podem ter um importante papel no cenário da DAJ nesta população.

Finalmente, sabe-se que as lesões esportivas são multifatoriais e complexas por natureza e, possivelmente, emergem de uma interação entre fatores preditivos, mas não de uma combinação linear e isolada entre eles (COFFEY,1998; BITTENCOURT et al., 2016). A título de exemplo, em um estudo conduzido por Bittencourt e colaboradores (2012), durante a realização de agachamento unipodal, a ocorrência de um ângulo de projeção frontal do joelho (APFJ) aumentado se associou à interação entre torque abdutor do quadril e à amplitude passiva de movimento do quadril. Baixo torque abdutor isométrico foi o principal preditor de APFJ. Entretanto, o torque isoladamente não foi capaz de explicar a ocorrência de APFJ aumentado, já que houve a necessidade de interação do mesmo com amplitude passiva de movimento do quadril aumentada para então haver associação com a ocorrência de APFJ. Estes resultados demonstraram interações complexas e não-lineares entre as variáveis e o desfecho. Portanto, o entendimento de como fatores preditores interagem pode ser crucial para guiar o desenvolvimento de estratégias curativas e preventivas. No que diz respeito à DAJ em ciclistas, além de suas causas não poderem ser estabelecidas até o presente momento (JOHNSTON et al., 2017), a análise e a descrição da interação entre seus fatores preditores ainda não foi explorada pela literatura corrente.

2. OBJETIVOS

2.1. Objetivo geral

Investigar a associação entre fatores musculoesqueléticos e de posicionamento sobre a bicicleta com a ocorrência de DAJ em ciclistas de *mountain bike*.

2.2. Objetivos específicos

Estudo 1: verificar a associação entre as variáveis cinemáticas do ciclista ao pedalar com a ocorrência de DAJ em ciclistas de *mountain bike* por meio de regressão logística.

Estudo 2: investigar as interações entre fatores musculoesqueléticos relacionados ao tronco, ao quadril e ao complexo tornozelo-pé associadas com a ocorrência de DAJ em *mountain bikers* por meio da análise da CART.

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4. ESTUDO 1

Association of cycling kinematics with anterior knee pain in mountain bikers

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ABSTRACT

Background: Biomechanical analysis of cyclists is commonly implemented to provide resources for injury prevention, however, to date literature is quite scarce in terms of description and analysis of cycling kinematic data associated to the occurrence of AKP in mountain bikers.

Purpose: To investigate, by means of logistic regression, the association of cyclists' kinematic variables while pedaling on the bicycle with the occurrence of anterior knee pain (AKP) in mountain bikers.

Study Design: Cross-sectional

Methods: Fifty subjects, divided in AKP group and no AKP group, had their kinematic variables while pedaling for 30 seconds on their own bicycles recorded using Retül motion analysis system. Linear and angular data from hip, ankle and foot were obtained. Binary logistic regression was performed to identify kinematic variables associated with AKP.

Results: Variables such as ankle maximum (AMAX), maximum knee flexion (MAXKF), maximum knee extension (MAXKE), and back angle (BACKA) were significant predictors of AKP, whereas knee forward of foot (KFOF), knee forward of spindle (KFOS), knee to foot lateral offset (KFLO), and hip to foot lateral offset (HFLO) were not. The model could adequately classify the outcomes in 72.0% of the cases.

Conclusion: Cyclists' plantar flexion, knee flexion, knee extension and trunk inclination during pedaling were significant predictors of AKP in mountain bikers, whereas knee and pedal alignment and knee-hip-foot alignment were not.

Key words: bike fitting, knee, kinematics, logistic regression, cycling.

What is known about the subject: There are no clear links to injury mechanism in cycling, but it has been suggested that cyclist's positioning on the bicycle may be one of the possible causes for overuse injuries, including anterior knee pain. Also, most preventive strategies for overuse injuries in cycling are based on optimizing body position on the bicycle. However, to date literature is quite scarce in terms of description and analysis of cycling kinematic data associated to the occurrence of AKP in mountain bikers.

What this study adds to existing knowledge: Ankle, knee and trunk kinematic variables during pedaling were associated with anterior knee pain in mountain bike cyclists. Clinicians should then take dynamic positioning on the bicycle into consideration when dealing with this condition in mountain bikers.

INTRODUCTION

Cycling is a worldwide popular activity, serving for transportation, physical conditioning, leisure and competitive sports practice[1]. Although traumatic injuries are very common in cyclists, in general, implementing strategies such as wearing protective equipment, keeping the bicycle in good mechanical conditions and adopting safe riding behaviors have been successful in reducing the incidence of traumatic injuries[1,2]. On the other hand, overuse injuries can be highly prevalent and may represent as much of a problem as acute injuries, occurring in up to 85% of cyclists[3]. More specifically, anterior knee pain (AKP) is the most common injury in cyclists with 36% of prevalence[4]. Therefore, considering the high prevalence and the significant time loss from sport participation associated with AKP[4], better understanding of the factors related to the occurrence of this health condition may help improve treatment and prevention strategies.

Biomechanical analysis of cyclists is commonly implemented in clinical practice to provide resources for injury prevention[5,6] and treatment because motion analysis helps to assess body position on the bicycle. On this perspective, joint kinematics measurement is commonly performed[7], since proper joint alignment may promote adequate transference and dissipation of internal and external forces on the kinetic chain, possibly improving performance and protecting different biological tissues from injuries[8]. In this issue, sagittal plane measures are the most common approaches because less motion is observed in frontal or transverse planes during sub-maximal steady-state cycling[9].

Although cyclist's positioning on the bicycle may be one of the possible causes for overuse injuries, including AKP[1,2,10-13], to date literature is quite scarce in terms of description and analysis of cycling kinematic data associated to the occurrence of AKP in mountain bikers. Therefore, the purpose of this study was to investigate the association of cyclists' kinematics while pedaling on the bicycle with the occurrence of AKP in mountain bikers. We hypothesized that dynamic body positioning, especially related to the knee joint, on the bicycle is associated with AKP in these athletes.

METHODS

Subjects

Certified professional mountain bikers by the State Federation of Cycling (Federação Mineira de Ciclismo - FMC) and amateur athletes of both sexes, during pre-season, were invited to participate in this study. The general inclusion criteria were (I) age ≥18 years old; both genders; (II) off-road week training volume greater than 25 Km; (III) a total week training volume greater than 100 Km (that could include training on a roller, a stationary bike or on a road bike). Participants were then included in the AKP group according to the presence of AKP during cycling (a minimum of 3 points in the 0-10 pain scale) lasting more than 3 months and ≤ 7 points of functional impact in the 0-10 Patient-Specific Functional Scale (PSFS). Otherwise, cyclists were included in the group without AKP in case of absence of AKP or other complaints during cycling on the last 3 months and ≥ 8 points of functional impact in the 0-10 PSFS. The general exclusion criteria were: (I) signs or symptoms suggesting red flags (e.g. unexpected weight loss, cauda equina symptoms); (II) history of trauma or surgical procedure in the spine or in the lower limbs on the last 12 months; (III) reporting AKP at rest or AKP greater than 7 points in the 0-10 pain scale; (IV) neurological disorders or pregnancy; (V) being para-cyclist.

Fifty subjects agreed to participate in this study, 26 with AKP and 24 without AKP. All participants signed the informed consent form approved by Universidade Federal dos Vales do Jequitinhonha e Mucuri (UFVJM) Ethics Research Committee (CAAE number 69764517.8.0000.5108).

Procedures/Evaluation

Participants had their characteristics assessed by the Cyclist Profile Questionnaire, Kujala Anterior Knee Pain Scale (AKPS), Victorian Institute of Sport Assessment Scale (VISA-P) and PSFS and kinematic data was collected during pedaling using Retül motion analysis system. All participants haven't trained or made any structured and systematic physical efforts 24 hours prior of the data collection.

Participants profile

All participants fulfilled the Cyclist Profile Questionnaire, AKPS, VISA-P and Patient Specific Functional Scale (PSFS) prior to kinematic data collection. Cyclist Profile Questionnaire was adapted from Fuller et al.[14] and Clarsen et al[4] to collect cyclists' anthropometric data, training features and injury history. AKPS is a condition-specific instrument used to assess patients with patellofemoral pain syndrome formed by 13 items relative to different functional levels of the knee. Existing categories within an item are ranked and answers are summed to get a global score of 100, representing “no deficit,” and 0, representing “the biggest deficit possible”[15]. Its measurement properties are acceptable, and it may be used to assess Brazilian patients with patellofemoral pain syndrome[16]. VISA-P is an eight-item questionnaire which approaches symptoms and dysfunctions related to patellar tendinopathy. The final score corresponds to severity of the condition in numerical terms, ranging from 0 to 100 points, with a maximal score indicating symptoms and disability absence[17]. It is highly reliable, shows appropriate construct validity and can be used in Brazil to evaluate and monitor changes over time in patients with patellar tendinopathy[18]. Since both AKPS and VISA-P investigate disabilities of daily living activities, PFFS was also fulfilled by all participants. They should classify their functional limitations in cycling practice (training or competitions) or in other activities because of the presence of AKP from 0 (unable to perform the activity) to 10 (able to perform the activity at the same level as pre-injury). This instrument shows good reliability, validity and sensitivity levels[19].

Kinematic variables

The Retül motion analysis system (Retül – Crucial Innovation, USA) was used to assess cyclists’ kinematic data during pedaling on their own bicycle. It has been developed specifically to asses dynamic positioning of cyclists and it is very popular in cycling field worldwide. According to the manufacturer, the system can be found in more than 400 bike fit sites in numerous countries of Asia, Africa, Europe, America and Australia and it has good accuracy, identifying cyclist’s body positioning every 2.1 milliseconds, with an error margin less than 1 degree and 1mm for each measurement. Participants had their own bicycle positioned and leveled on a CycleOps PowerBeam training roller (Saris Cycling Group – USA). While on the bicycle, Retül systems LED sensors were placed directly on the cyclist’s skin with adhesive markers and then the cyclist pedaled at cadence of 90 revolutions per minute (rpm) with a resistance of 200 W[5] for 50 seconds (manufacturer's recommendation). Motion analysis was performed for 30 seconds on the symptomatic side (AKP group) or the dominant side (no AKP group) according to the Retül System protocol of data acquisition. The first and the last 10 seconds of pedaling were excluded to avoid unusual body positioning and movement patterns, since they were acceleration and deceleration phases, respectively.

Retül system provides 34 variables, some angular and some linear. We performed a survey with 21 Retül certified fitters in Brazil to check for the most frequent variables used to perform cyclists' motion analysis on the bike which resulted in the following 13 variables: back angle (BA), maximum knee flexion (MAXKF), maximum knee extension (MAXKE), ankle maximum (AMAX), ankle minimum (AMIN), ankle angle at top (AAAT), ankle angle at front (AAAF), ankle angle at bottom (AAAB), ankle angle at rear (AAAR), knee forward of foot (KFOF), knee forward of spindle (KFOS), knee to foot lateral offset (KFLO), hip to foot lateral offset (HFLO). Therefore, those variables were extracted and analyzed from data acquisition in the present study. It's worth mentioning that Retül System isolates each pedal stroke within a capture period and average measurements across those pedal strokes for lower limb data while upper limb and torso measurements represent averages of the entire capture period.

The 13 variables are defined as follows: AMAX - maximum plantarflexion at any point in the pedal stroke defined by the knee-ankle line and the heel-foot-line; AMIN - maximum dorsiflexion at any point in the pedal stroke defined by the knee-ankle line and the heel-foot-line; AAAT - ankle angle at the top of the pedal stroke (0º of the crank cycle); AAAF - ankle angle at the front of the pedal stroke (90º); AAAB - ankle angle at the bottom of the pedal stroke (180º); AAAR - ankle angle at the rear of the pedal stroke (270º); MAXKF - maximum flexion of the knee joint at any point in the pedal stroke defined by the hip-knee line; MAXKE

- maximum extension of the knee joint at any point in the pedal stroke defined by the hip-knee line; BA - angle of the trunk relative to the horizon defined by the hip and shoulder. Also, here are the definitions for linear variables: KFOF - horizontal antero-posterior offset of the knee relative to the pedal spindle at 3 o'clock in the pedal stroke (90º); KFOS - horizontal antero-posterior offset of the knee relative to the foot at 3 o'clock in the pedal stroke (90º); KFLO - lateral horizontal offset between the knee and foot on the frontal plane (negative values indicate that the foot is outside the knee or knee valgus); HFLO - lateral horizontal offset between hip and foot on the frontal plane (negative values indicate that the hip is outside the foot).

Mean angular measures during the 30-second analysis period for trunk (BA), knees (MAXKF and MAXKE) and ankles (AMAX, AMIN, AAAT, AAAF, AAAB, AAAR), as well as mean linear measures for ankle, knee and hip alignment (KFOF, KFOS, KFLO, HFLO) were obtained. A previous pilot study was conducted with 10 participants (8 men; 2 women; mean age of 46.6 years; mean body mass of 75.9 kg; mean height of 1.79 m) to test intra-tester reliability and standard error for each of the aforementioned variables measures. Good to excellent reliability levels have been found for all of them (table 1).

Statistical Analysis

Statistical analyses were carried out using the SPSS® statistical package, version 19.0 (SPSS Inc., Chicago, IL, USA) for Windows®. Independent t-tests and Mann-Whitney U-tests were used to compare the mean values for variables presenting continuous data for normal and non-normal distributions, respectively. Pearson's correlations were used to evaluate the bivariate correlations between all variables. To minimize the effects of multicollinearity, variables with the highest correlations ($r > 0.7$) were not included in the regression model. Binary logistic regression was to assess the association of the kinematic measures with the occurrence of AKP. Statistical significance was set at $\alpha \leq 0.05$.

Table 1 Reliability of the Retül system variables

	$ICC_{3,3}$	SE	95% CI
AMAX	0.87	2.00	0.48-0.96
AMIN	0.86	1.10	0.40-0.97
AAAT	0.88	2.96	0.52-0.97
AAAF	0.91	1.97	0.63-0.8
AAAB	0.84	1.19	0.35-0.96
AAAR	0.82	1.44	0.31-0.95
MAXKF	0.87	0.68	0.51-0.97
MAXKE	0.98	1.73	0.94-0.99
BA	0.99	2.59	0.98-0.99
KFOF	0.83	4.3	0.32-0.95
KFOS	0.82	5.43	0.23-0.96
KFLO	0.99	4.93	0.96-0.99
HFLO	0.95	3.80	0.83-0.99

$ICC_{3,3}$, intraclass correlational coefficient; CI, confidence interval; AMAX, ankle maximum; AMIN, ankle minimum; AAAT, ankle angle at top; AAAF, ankle angle at front; AAAB, ankle angle at bottom; AAAR, ankle angle at rear; MAXKF, maximum knee flexion; MAXKE, maximum knee extension; BA, back angle; KFOF, knee forward of foot; KFOS, knee forward of spindle; KFLO, knee to foot lateral offset; HFLO, hip to foot lateral offset

RESULTS

There were no differences in age, height and mass between AKP and no AKP groups. However, these groups exhibited significant differences in mean values for AKPS, VISA-P and PSFS scores (p=0.0001), with values around 84, 81 and 7, respectively for the AKP group and 95, 96 and 10 for the no AKP group. Also, both groups were not different in terms of training aspects, except for mean time in elite sports practice (p=0.024), with the AKP group exhibiting around 3 years of sports practice and the group without AKP less 1 year (table 2).

Ankle variables (i.e. AAAT, AAAF, AAAB and AAAR) demonstrated positive correlations with each other with r > 0.7. Therefore, among these variables, only AMAX was included in the regression model, since it demonstrated the highest correlation with the dependent variable (i.e. group variable).

The model containing AMAX, MAXKF, MAXKE, and BA was significant [X^2 (8) = 22.05; p = 0.004, $R^2_{\text{Negelkerke}}$ = 0.479; Hosmer and Lemeshow Test X^2 = 7.741; p = 0.459]. Variables such as AMAX, MAXKF, MAXKE, and BA predicted the occurrence of AKP (table 5). Also, the model adequately classified participants in the AKP and in the no APK group the outcomes in 72.0% of the cases, in contrast with 52.0% for the baseline model (without any independent variables).

Table 3 provides joint ranges of motion and alignment for both groups.

DISCUSSION

This study investigated the association of cyclists' kinematics with the occurrence of AKP in mountain bikers. The results demonstrated that increased maximum ankle plantarflexion (AMAX), increased maximum knee flexion (MAXKF), decreased maximum

Table 2 Mean (SD) of the anthropometric features, questionaries' scores and training characteristics of the participants in the AKP and no AKP groups with statistical comparisons.

	Total (n=50)		AKP group (n=26)	No AKP group (n=24)	Group comparison test
	Mean (SD)	Min-Max	Mean (SD)	Mean (SD)	p Value
Age (years)	37.1 (6.77)	21-56	35.54 (5.64)	38.79 (7.58)	0.090
Hight (meters)	1.74 (0.08)	1.55-1.89	1.75 (0.07)	1.74 (0.08)	0.599
Weight (kilos)	75.42 (14.30)	50-118	76.59 (12.02)	74.14 (16.59)	0.550
AKPS (points)	89.20 (10.24)	62-100	83.77 (10.41)	95.08 (6.06)	0.0001*
VISA-P (points)	88.08 (12.89)	46-100	81.03 (14.04)	95.71 (4.82)	0.0001*
PSFS (points)	8.46 (2.12)	3-10	7.15 (2.22)	9.88 (0.45)	0.0001*
Time of sports practice (years)	8.04 (6.48)	1-30	7.54 (6.95)	8.58 (6.03)	0.292
Time in elite sports (years)	2.08 (3.66)	0-15	3.15 (4.55)	0.92 (1.86)	0.024*
Week training frequency	3.76 (1.31)	1-6	4.00 (1.41)	3.50 (1.18)	0.155
Mean training duration (minutes)	137.04 (33.21)	90-240	145.08 (36.20)	128.33 (27.81)	0.094
Mean training distance (Km)	42.53 (10.49)	24-65	42.25 (10.13)	42.83 (11.08)	0.847
Longest training duration in 2017 (hours)	6.45 (2.12)	2-13	6.72 (2.17)	6.17 (2.08)	0.304
Longest training distance in 2017 (Km)	122.43 (45.69)	49-280	125.00 (52.79)	119.64 (37.43)	0.683
Race participation in 2017 (days)	6.76 (8.16)	0-30	7.84 (7.09)	5.58 (9.18)	0.108

SD, standard deviation; min; Minimum; Max, maximum.

*p ≤0.05

Table 3 Mean (SD) of joint ranges of motion and alignment of the participants in the AKP and no AKP groups.

	Total (n=50)		AKP group (n=26)	No AKP group (n=24)
	Mean (SD)	Min-Max	Mean (SD)	Mean (SD)
AMAX	98.16 (7.99)	74-114	100.04 (7.24)	96.42 (8.39)
MAXKF	112 (3.57)	106-121	112.83 (3.85)	111.23 (3.18)
MAXKE	38 (6.15)	27-52	37.79 (6.21)	38.19 (6.20)
BA	54.82 (5.41)	40-68	54.21 (6.27)	55.38 (4.53)
KFOF	-13.62 (27.31)	-71-55	-7.79 (30.06)	-19.00 (23.83)
KFOS	-21.30 (-29.23)	-78-39	-14.04 (28.15)	-28.00 (29.13)
KFLO	20.20 (23.07)	-40-102	22.75 (24.86)	17.85 (23.55)
HFLO	8.34 (16.07)	-57-41	5.79 (17.83)	10.69 (14.20)

SD, standard deviation; min; minimum; max, maximum; CI, confidence interval; AMAX, ankle maximum; MAXKF, maximum knee flexion; MAXKE, maximum knee extension; BA, back angle; KFOF, knee forward of foot; KFOS, knee forward of spindle; KFLO, knee to foot lateral offset; HFLO, hip to foot lateral offset

knee extension (MAXKE) and decreased angle of the trunk relative to the horizon (BA) during pedaling were associated with the occurrence of AKP in cyclists. On the other hand, knee and foot alignment in the sagittal plane, and hip, knee and ankle alignment in the frontal plane while pedaling were not associated with AKP. The logistic regression model demonstrated that increased ankle plantarflexion during pedaling reduced in 1.16 times the chance of having AKP. Musculoskeletal system presents specific features related to its functioning. Specially, anatomic linkage of body segments causes movement interdependence among them[8,20]. This interdependence (kinetic chain) allows the system to deal with internal and external forces imposed to the body during sports activities[20].

Table 5 Variables in the equation of the binary logistic regression

	p Value	OR	95% CI
AMAX	0.013*	0.857	0.759 – 0.968
MAXKF	0.010*	0.583	0.388-0.879
MAXKE	0.029*	1.249	1.022-1.525
BA	0.016*	1.316	1.053-1.646
KFOF	0.642	0.988	0.938-1.040
KFOS	0.180	0.962	0.909-1.018
KFLO	0.233	1.032	0.980-1.086
HFLO	0.278	1.039	0.969-1.115

OR, Odds Ratio; CI, confidence interval; AMAX, ankle maximum; MAXKF, maximum knee flexion; MAXKE, maximum knee extension; BA, back angle; KFOF, knee forward of foot; KFOS, knee forward of spindle; KFLO, knee to foot lateral offset; HFLO, hip to foot lateral offset

*$p \leq 0.05$

As such, adequate transference and dissipation of those forces on the kinetic chain may improve performance and protect different biological tissues from injuries[8]. On this perspective, sports injuries occur when the amount of mechanical energy transferred to the body exceeds tissue adaptation threshold[21,22]. Particularly, factors that promote energy concentration on a specific tissue may have origin on the target tissue itself (local factors) or on anatomically distant segments (non-local factors)[23,24]. Knee and hip extensors are the main responsible for energy generation during the propulsive phase of the pedaling cycle[25]. However, the energy produced by theses muscles depend on the simultaneous action of the ankle plantarflexors to be delivered to the bicycle crank, since they do not cross the ankle[26]. This synchronous relationship between hip and knee extensors and ankle plantarflexors is the lower limb extensor synergy, which allows the energy flow through the kinetic chain. Considering this interdependence among hip, knee and ankle joints and muscles during pedaling, malfunctioning of one of these may overload proximal and distal structures in the kinetic chain[24]. In this context, the association between reduced ankle plantarflexion angle and the occurrence of AKP suggests that reduced contribution of the ankle movement and muscles overload the knee and the quadriceps and consequently contribute to the development of AKP in cyclists. This result may be explained by ankle plantarflexors weakness in cyclists with AKP, which should be investigated in future studies.

Reduced knee flexion increased in 1.72 times the chance of having AKP and increased knee extension increased it in 1.2 times. Considering that cyclic forces applied to the knee joint at higher knee flexion angles may result in soft tissue damage[27], we hypothesized that increased knee flexion angle would be associated with AKP in cyclists. More specifically, the pathomechanical model for AKP suggests that increased knee flexion increases the compression component of the patellofemoral reaction force in individuals with AKP[28,29,30]. However, a previous study demonstrated that cyclists with increased knee flexion while pedaling did not demonstrate increased patellofemoral compressive forces[31], which suggests that increased knee flexion angles may not linearly relate to increased patellofemoral compressive forces in cyclists[32]. Alternatively, it is possible that the cyclists with AKP assume increased knee flexion angles as a compensatory mechanism to reduce knee pain levels. In fact, previous studies have demonstrated that individuals with AKP may exhibit compensatory knee flexion angles during functional tasks[33-36] as a strategy to minimize joint loading[28] and consequently reduce pain. Our results demonstrate that this can also be true for cyclists with AKP.

Reduced trunk flexion increased in 1.3 the chance of having AKP. Trunk position is related to changes in lower limb muscles' activation during cycling[37], which may affect transmission of energy to the bicycle crank. For example, greater trunk flexion was related to smaller pulling force at the recovery phase of the pedaling cycle in triathletes[38,39]. Besides, alterations in trunk inclination may influence the activity of core muscles. Core stability contributes to lower extremity mechanics in cycling, since core fatigue increases knee frontal and sagittal plane range of motion[40]. Thus, reduced trunk flexion may increase loading on cyclists' knee, which may help to explain the association of reduced trunk flexion with AKP in this study. Considering that trunk position may be easily adjusted during pedaling, increasing trunk flexion may be used as a strategy to reduce joint loading and consequently reduce pain in cyclists with AKP, which however is speculative at this point.

Linear horizontal positioning of the foot to the pedal spindle on the sagittal plane is commonly used to assess cyclist positioning in clinical practice. It is recommended that the vertical projection of the knee should intersect the pedal axis since knee positions forward of the pedal may result in higher compressive forces on patellofemoral joint[41]. Ricard et al[42] and Bini et al[43] observed that more forward position of the body on the bicycle resulted in different muscle activation on the lower limbs. These results suggest that towards a more forward position on the bicycle, cyclists shifted force drivers from hamstrings to quadriceps. However, when the horizontal position of the foot on the pedal was varied (forward or backward), no significant effects on knee joint forces[43], muscle activity[44], pedal forces[45], or oxygen uptake[46] were observed. Our findings are in conjunction with that, since KFOF and

KFOS were not included in the regression model. Also, AKP group means for both variables were around -8 mm and -14 mm, respectively, indicating that the knee is backward to foot, putting the forward position of the knee relatively to the foot as a possible associated factor to AKP into question. Therefore, there is still no current evidence to support that horizontal alignment of the knee relatively to the foot on the bicycle is associated to AKP.

Cyclists presenting AKP exhibit altered knee motion on the frontal plane with medialization of the knee relatively to the ankle, especially during the propulsive phase of pedaling (when knee reaches extension)[5]. This excessive movement has been identified as a contributor to AKP[47] and may enhance the risk of knee injury due to overload[40]. Although we haven't measured knee motion on the frontal plane (varus or valgus), it was estimated using linear measures of foot relatively to knee and hip collected by the motion analysis system. A similar model has been used by Kagaya, Fujii, Nishizono[48] which also collected linear measures related to assess dynamic knee valgus. Usual recommendations are that the knee should remain directly over the pedal axis in the frontal plane during the pedaling cycle[49]. However, it has been shown that the knee usually moves medially during the propulsive phase of the pedaling cycle and laterally during the recovery phase[5]. Yet, the amount of medial knee movement that is tolerated is still unknown even though cyclists with AKP showed greater medial knee displacement than cyclists without AKP[5]. That indicates that excessive medial knee movement may be associated with knee pain. Conversely, our results could not significantly associate KFLO and HFLO with the occurrence of AKP. Also, the mean values of those variables for the AKP group were approximately 23 and 6 respectively, which demonstrate knee varus indirectly. As such, associations of augmented medial knee displacement in mountain bikers with AKP were not confirmed by this study.

The present study had some limitations. Differences between groups in terms of cycling experience were found, with the AKP group exhibiting more time in elite sports practice (mean around 3 years). This could impact on lower limbs kinematics. Comparisons of novice and experienced cyclists showed that experienced cyclists presented lower variability in activation of lower leg muscles[50-52], which may influence pedaling kinematics. Moreover, differences in ranges of motion for hip, knee and ankle in cycling were found between cyclists with varying experience[50]. However, differences between novice and experience cyclists were not applicable to knee and ankle mean angles and range of motion[6], variables which showed association to AKP in our results. Further studies controlling experience between groups should be done to clarify that.

Moreover, another possible limitation of the study is related to not exploring transverse plane knee kinematics as possible associated factors to AKP since we may expect that cyclists with larger motion in non-sagittal planes could also be at larger risk of overuse injuries like those observed for runners[53]. Also, workload level was also found to affect ankle[54] and knee joint angles[55] and cadence could also lead to different muscle activation, which might affect limb kinematics. Our study established a resistance and cadence of 200W and 90 rpm, respectively, since that is usually similar to cyclists self-selected pedaling cadence[6]. Arbitrarily using these parameters may have affected cyclists usual motion pattern and consequently influenced the results of this study. Further studies comparing different cadence and workloads should be conducted to test that.

Finally, this study suggests that ankle, knee and trunk kinematic variables during pedaling in mountain bikers require attention due to their association to AKP. Clinicians should then take dynamic positioning on the bicycle into consideration when dealing with AKP in mountain bike cyclists.

CONCLUSION

In summary, increased maximum ankle plantarflexion, increased maximum knee flexion, decreased maximum knee extension and decreased angle of the trunk relative to the horizon during pedaling were significant predictors of AKP in mountain bikers, whereas hip, knee and ankle alignment in the frontal plane while pedaling were not. Thus, health care professionals dealing with injured athletes or trying to prevent cycling injuries need to analyze athletes' dynamic body positioning on their own bicycle. Finally, previous anecdotal suggestions that cyclist's positioning on the bicycle could be associated to AKP were confirmed.

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5. ESTUDO 2

Interaction of foot and hip factors predicts anterior knee pain in mountain bikers

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ABSTRACT

Objectives: To investigate interactions of trunk, hip, and foot/ankle factors associated with the occurrence of anterior knee pain (AKP) in mountain bikers using CART analysis.

Methods: Fifty subjects, divided in AKP group and no AKP group, were assessed on bridge test with unilateral knee extension, hip stability isometric test, passive hip internal rotation (IR) range of motion (ROM), shank-forefoot alignment (SFA), and ankle dorsiflexion ROM. CART analysis was performed to identify interaction among the analyzed factors associated with AKP. In order to verify the accuracy of the model, a receiver-operating characteristic (ROC) curve was created. Lastly, to investigate the strength of associations, prevalence ratios were calculated for each terminal node of the CART model.

Results: Interactions among passive IR ROM, HipSIT, ankle dorsiflexion ROM and SFA identified mountain bikers with and without AKP. The model achieved 76.9% sensitivity and 87.5% specificity. The area under the ROC curve was 0.86 (95% confidence interval: 0.75 - 0.97; standard error 0.05; $p<0.0001$).

Conclusion: The occurrence of AKP in mountain bike cyclists was associated with an interaction among passive hip IR ROM, HipSIT and ankle dorsiflexion ROM. CART analysis captured nonlinear and complex interactions among those variables, indicating that the contribution of one factor depends on the presence of other factors.

Key words: knee, injury, decision trees, cycling.

INTRODUCTION

Prevalence of overuse injuries can be extremely high in cycling, with rates reaching around 85%.[1] Of all overuse conditions affecting cyclists, anterior knee pain (AKP) is the most common condition of the knee joint, showing prevalence of 36%.[2] Besides, AKP is also the most significant health problem affecting professional cyclists, as it promotes considerable sports participation time loss.[2] Some authors indicate possible associations between bike positioning and knee injury,[3-8] but that has not been analyzed yet.[9] Moreover, those aspects may not be the only causes for AKP and cyclists' personal factors (e.g. strength, passive joint range of motion) may also play a role in this injury occurrence.

Cyclists presenting AKP exhibit altered knee motion on the frontal plane with medialization of the knee relative to the ankle specially during the propulsive phase of pedaling (when knee moves from flexion to extension).[10] This excessive movement has been identified as a contributor to anterior knee pain[11,12] and might enhance the risk of knee injury due to overload[13]. Abt et al[13] showed that alteration in core stability was linked to increased frontal plane knee motion in cyclists with AKP. Moreover, increased hip internal rotation (IR) or hip adduction were also observed in association with increased knee motion on the frontal plane during weight-bearing activities in asymptomatic participants[14] and individual with patellofemoral pain.[15] This movement pattern may occur due to decreased hip passive resistance to motion (stiffness)[16] and weakness of the hip abductor and external rotator muscles.[17,18,19] As well, because of coupling between rearfoot eversion with lower limb IR,[21] foot pronation can also lead to lower limb IR.[22] That may be explained by the orientation of the subtalar joint axis, which couples frontal plane foot motion (calcaneal eversion) with transverse plane motion (talus and lower limb IR).[23] Thus, changes in subtalar joint motion may contribute to knee joint misalignment. [24] Since excessive pronation has been associated with the presence of forefoot varus,[22,24] foot alignment may also be related to excessive frontal plane knee motion.[26,27] Another contributor to load intensification on the knee joint is restriction of ankle dorsiflexion, which increased the risk for AKP.[28,29] Due to the possible reduced capacity of energy absorption at the ankle, load on the knee joint may emerge as a compensatory mechanism. Accordingly, the presence of altered core stability, hip abductor and external rotators weakness, range of motion impairments at the hip joint and anatomical alignment at the foot/ankle complex may influence lower extremity movement patterns and, consequently, alter the force distribution on the knee joint structures.[30-36]

Sports injuries are multifactorial and complex by nature and they possibly emerge from an interaction among predictive factors, but not from the linear and isolated combination of them.[37,38] For example, in a study conducted by Bittencourt el al,[30] during single-leg squatting, the occurrence of high frontal plane knee projection angle (FPKPA) was associated with an interaction between hip abductor torque and passive hip IR ROM. Low hip abductor isometric torque was the main predictor of high FPKPA. However, torque alone could not explain the occurrence of increased FPKPA since it had to interact with increased range of passive hip IR to be associated the occurrence of high FPKPA. These findings showed nonlinear and complex interactions between the variables to the outcome. Therefore, understanding how predictive factors interact is crucial to guide therapists in developing effective prevention strategies. Having said that, to fully uncover this complex nature of sports injury etiology, a complex systems approach is necessary. Statistical methods which include linear and non-linear associations and the identification of interaction effects, such as CART, should then be used.[38,39] Thus, the objective of this cross-sectional study was to investigate interactions of trunk, hip, and foot/ankle factors associated with the occurrence of anterior knee pain (AKP) in mountain bikers using CART analysis.

METHODS

Participants

Fifty male and female professional and amateur mountain bikers agreed to participate in the study during pre-season. Inclusion criteria consisted of: a minimum of 18 years old; both genders; off-road week training volume greater than 25 Km and a total week training volume greater than 100 Km (that may include training on a roller, a stationary bike or even a road bike). Cyclists were excluded from the study if they had signs and symptoms suggesting red flags (i.g. unexpected weight loss, cauda equina symptoms), had suffered any trauma or underwent any surgical procedure in the spine or in the lower limbs on the last 12 months, had any AKP during rest, had any neurological disorders diagnosed, were para-cyclists, were pregnant, had AKP greater than 7 points in the 0-10 pain scale during data collection or were not able to perform the data collecting procedures. Participants were then allocated in two different groups: 1) group with AKP (n=26), according to the presence only of AKP during cycling (a minimum of 3 points in the 0-10 pain scale) lasting more than 3 months and a minimum of 3 points of functional impact in the 0-10 Patient-Specific Functional Scale (PSFS);[40] and 2) group without AKP (n=24), exhibiting no AKP or other complaints during cycling on the last 3 months and a minimum of 7 points of functional impact in the 0-10 PSFS. All athletes were informed that participation was voluntary and all information they provided was secret and would be used only for the research purposes. The study was approved by the UFVJM Ethics Research Committee (CAAE number 69764517.8.0000.5108) and every cyclist gave his/her informed consent before participation.

Clinical Assessment

Cyclist Profile Questionnaire, Kujala Anterior Knee Pain Scale (AKPS), Victorian Institute of Sport Assessment Scale (VISA-P), and Patient Specific Functional Scale (PFPS) were fulfilled by every participant prior to clinical assessment to better describe sample characteristics. Cyclist Profile Questionnaire was adapted from Fuller et al[41] and Clarsen et al[3] to characterize cyclists in terms of anthropometric and training features, as well as injury history. AKPS is a condition-specific instrument used to assess patients with patellofemoral pain syndrome formed by 13 items relative to different functional levels of the knee. Existing categories within an item are ranked and answers are summed to get a global score of 100 representing "no deficit" and 0 "the biggest deficit possible".[42] Its measurement properties are acceptable, and it may be used to assess Brazilian patients with patellofemoral pain syndrome.[43] VISA-P is an eight-item questionnaire which approaches symptoms and dysfunctions related to patellar tendinopathy. The final score corresponds to severity of the condition in numerical terms, ranging from 0 to 100 points, with a maximal score indicating symptoms and disability absence.[44] It is highly reliable, shows appropriate construct validity and can be used in Brazil to evaluate and monitor changes over time in patients with patellar tendinopathy.[45] Since both previous questionnaires investigate disabilities of daily living activities, PFPS was also fulfilled by all participants. They should classify their functional limitations in cycling practice (training or competitions) or in other activities because of the presence of AKP from 0 (unable to perform the activity) to 10 (able to perform the activity at the same level as pre-injury). This instrument shows good reliability, validity and sensitivity levels.[46]

Clinical measures included assessment for impairments of the trunk, hip and foot/ankle including: bridge test with unilateral knee extension, hip stability isometric test (HipSIT), passive hip IR ROM, shank-forefoot alignment (SFA), and ankle dorsiflexion ROM. Tests were performed in the following sequence: ankle dorsiflexion ROM, bridge test with unilateral knee extension, passive hip IR ROM, HipSIT, and SFA. Mean measures of three trials were obtained for each variable. A previous pilot study has been conducted with 9 participants (4 men; 5 women; mean age of 34.0 years; mean body mass of 61.9 kg; mean height of 1.65 m) to allow intra-tester reliability and standard error of measure for each of the aforementioned variables. Good to excellent reliability levels have been found for all of them (table 1). All participants haven't trained or made any structured and systematic physical efforts 24 hours prior of the data collection.

INSERT TABLE 1 ABOUT HERE

Ankle dorsiflexion ROM was assessed using the protocol described by Bennell et al.[48] Participants were positioned facing a wall on which a vertical line has been drawn previously and were instructed to move their knees forward until they touched it. The foot should be maintained on this line without lifting the heel off the floor (Figure 1). An analogical inclinometer (AM-2, Starrett®, Athol, USA) was placed 15 cm distally from the tibial tuberosity to define maximum shank anterior inclination (ankle dorsiflexion ROM). The three measurements performed were averaged for analysis.

INSERT FIGURE 1 ABOUT HERE

Since bridge test with unilateral knee extension is moderately correlated to lab measures of core stability,[48] it was used to assess pelvic stabilizing capacity. According to Andrade et al[49] and Santos et al[50], athletes laid on treatment table in supine position with knees and hips flexed, plantar aspects of the feet in contact with the supporting surface and keeping their hands behind the head. A reflexive marker was positioned on each anterior-superior iliac spine (ASIS) and participants were asked to elevate their pelvis from the treatment table. Holding that position, they should extend the knee until their thighs were leveled and keep it for 10 seconds. Immediately after that, they returned to the starting position and repeated the procedure with the opposing lower limb (Figure 2A). For data recording, right side was considered when the right lower limb was in contact with the supporting surface and vice versa. A digital camera (Sony Cyber-shot®, model DSC-W330; Sony Corporation, Tokyo, Japan) was positioned perpendicular to the treatment table to film and capture of pelvic drop (angle formed between the line connecting both ASIS and the transverse plane quantified by Kinovea® software) (FIGURE 2B).

INSERT FIGURE 2 ABOUT HERE

To assess passive hip IR ROM, the examiner applied the protocol described by Carvalhais et al[51] in which participants were positioned prone on a treatment table with their knees flexed to 90º. Prior testing, the examiner moved passively the hip joint to produce tissue's viscoelastic accommodation. Passive hip IR movement, produced by the weight of the leg and foot was allowed until tension in muscle and passive structures of the hip joint themselves stopped this movement (Figure 3). That is, the end position was one in which the torque produced by the mass of the lower leg and foot was equal to the passive-resistance torque generated to prevent further hip IR, reflecting hip passive stiffness.

Passive hip IR ROM was measured with an analog inclinometer positioned 5 cm distally from the tibial tuberosity and the mean of 3 measures (in degrees), was used for analysis.

INSERT FIGURE 3 ABOUT HERE

Hip Stability Isometric Test (HipSIT) was performed using the protocol described by Almeida et al,[52] who demonstrated excellent intra and intertester reliability, good to moderate validity in identifying strength deficits in patients with patellofemoral pain. A handheld dynamometer (HHD) (Lafayette Manual Muscle Test System®, model 01165; Lafayette Instrument Company, Lafayette, IN, USA) was used to assess strength of the hip posterolateral stabilizers. This instrument is largely used in scientific research and clinical practice to measure muscle strength as it is easy to handle, portable and has good reliability (specially reliability to assess strength of hip muscles) and validity compared to isokinetic dynamometer (gold standard for evaluations of strength).[53,54] Cyclists laid on a treatment table in sideling, with both lower extremities positioned flexed at the hips (45°) and knees (90°), with the limb to be tested superior to the opposing limb (Figure 4). Participants were instructed to lift their knees of the superior leg while keeping the heels in contact until the hip was in 20° of abduction. HHD positioning was meticulously monitored based on the parameters described by Almeida et al[21] and Robinson & Nee. [55] To mitigate the influence of the rater, a strap was used for all tests. Then, proper test performance was demonstrated, and participants were asked to complete the test generating the greatest possible force for 5 seconds by separating the knees without losing feet contact. They performed 1 practice trial, rested for 30 seconds, and then performed the measured trials. Three tests were performed, with a 30-second rest between them. Mean values were calculated for each participant. When compensation was identified, values were discarded, and a new evaluation was done after 20 seconds. Muscle strength (Newtons) data were normalized by the body mass (kilograms) of each participant (strength/body mass).[21]

INSERT FIGURE 4 ABOUT HERE

SFA was measured according to Mendonça et al[56] with the participant lying prone on a treatment table. Bisection of the shank by a line joining the midpoint of the tibial plateau and the midpoint between the medial and lateral malleolus was done. A metal rod was strapped along the line of the plantar aspect of metatarsal heads. Participants actively maintained neutral position of ankle joint (90º) and the examiner took a picture of foot position with a digital camera (Sony Cyber-shot®, model DSC-W330; Sony Corporation, Tokyo, Japan). The SFA was determined using SAPO® software as the angle between the shank bisection line and the orientation of metal rod positioned on forefoot (Figure 5). Positive values indicated varus alignment. Mean SFA determined from 3 photos was used for analysis.

INSERT FIGURE 5 ABOUT HERE

For all the procedures aforementioned, participants were assessed bilaterally and data from the injured or most symptomatic lower limb, for the athletes with AKP, and the dominant lower limb in athletes without AKP were considered for analysis.[30,57] Limb dominance was identified by asking participants which leg they would choose to kick a ball.

Statistical Analysis

Statistical analyses were carried out using the SPSS® statistical package, version 19.0 (SPSS Inc., Chicago, IL, USA) for Windows®. Independent t-tests and Mann-Whitney U-tests were used to compare the mean values for continuous data for parametric and non-parametric distributions, respectively (statistical significance was accepted at the level of $\alpha \leq 0.05$). Descriptive statistics of Cyclist Profile Questionnaire, AKPS, VISA-P, PFPS age, height, weight, ankle dorsiflexion ROM, bridge test with unilateral knee extension, passive hip IR ROM, HipSIT, and SFA were used to characterize the sample. Classification and Regression Tree (CART) was used to determine which factors and interactions were associated with the presence or absence of AKP. This model is a nonparametric statistical method which recognizes mutually exclusive subgroups of a population whose members share common features effecting the dependent variable of interest. An examination of all possible splitting variables is done, and the model selects the one that best classify the population in binary groups. The initial population is gathered in an initial node which then branches into two descendent, or child, nodes according to the best predictors and their respective cutoff points that best classify the individuals into each of the outcome categories (for the present study, presence or absence of AKP).[58] Predictors are selected based on the strength of association with the outcome variable (AKP occurrence) and the divisions reveal interactions among predictors. Criteria used to produce the partitions in the present study were: a minimum of 8 participants in each node to make a division; a minimum of 4 participants to generate a node and a Gini diversity index of 0.0001 to maximize the nodes homogeneity. The classification cost was considered equal between categories and AKP occurrence probability was established based on a training sample. After CART model development, a receiver-operating characteristic (ROC) curve was created to verify the accuracy of the model.[58] A probability of type I error of 0.05 was used to verify if the area under ROC curve was different from 0.5, which indicates that the model was accurate to predict the outcome categories. Finally, prevalence ratios were calculated for each terminal node of the CART model to investigate the strength of associations. The choice for CART to analyze the data was based on its robust analysis, which captures nonlinear relationships between predictors and produces results easily applied in clinical practice.[58]

RESULTS

Groups Characteristics

There were no significant differences between AKP and no AKP groups with respect to their mean age, height, weight and weight. However, these groups exhibited significant differences in mean values for AKPS, VISA-P and PSFS scores (p=0.0001) Also, both groups were not different in terms of training aspects, except for mean time in elite sports practice (p=0.024) (table 2).

INSERT TABLE 2 ABOUT HERE

Classification and Regression Tree

Classification tree identified passive hip IR ROM, HipSIT, ankle dorsiflexion ROM and SFA as predictors for AKP occurrence. Passive hip IR ROM was the first predictor selected by CART with a cut-off of 15.00º. In individuals with lower values of passive hip IR ROM, HipSIT was the second predictor with a cut-off point of 3.11º N/Kg. In the presence of more than 3.11º N/Kg in Hip SIT values, SFA was selected as the third predictor with cut-off points of 0.50º. For individuals with passive hip IR ROM values above the cut-off point, the model selected ankle dorsiflexion ROM cut-off point (46.7º) on as another predictor.

The model indicated that the interaction of lower values of passive hip IR ROM with lower values of HipSIT was the best at predicting AKP occurrence (Terminal Node 3). On the other hand, AKP absence was best predicted by the interaction of passive hip IR ROM above 15.0º and interaction of lower ankle dorsiflexion ROM (Terminal node 5). The interactions representing AKP presence/absence profiles and are illustrated in Figure 6.

Table 3 provides the prevalence ratios for each terminal node, and the strength of the associations of predictors with the outcome. Results indicated that the interactions among predictors of nodes 3 and 5 were statistically associated with the absence or presence of AKP respectively.

INSERT FIGURE 6 ABOUT HERE

INSERT TABLE 3 ABOUT HERE

CART model predicted correctly 20 of the 26 cyclists with AKP (76.9% sensitivity) and 21 of the 24 athletes without AKP (87.5% specificity). The total prediction of the model was 82.0% and the area under the ROC curve was 0.86 (95% confidence interval: 0.75 - 0.97; standard error 0.05; $p<0.0001$) indicating that the model's classification was not due to chance.

DISCUSSION

The main findings indicated that CART model revealed that interactions among passive hip IR ROM, HipSIT, ankle dorsiflexion ROM and SFA were associated with the presence or absence of AKP. It is important to highlight that no variable in isolation could predict the outcome, meaning that AKP occurrence or absence was based on the association of predictors. Therefore, risk and protective profiles for AKP in mountain bikers could be identified. Overall, the model identified accurately 76.9% of cyclists with AKP and 87.5% of athletes without AKP.

Passive hip IR ROM, HipSIT and Dorsiflexion ROM

The first predictor selected by CART was passive hip IR ROM, which can be interpreted as passive hip stifness,[51] with a cut-off point of 15º. Athletes with lower values of passive hip IR ROM (<15º), in the presence of values of HipSIT lower than 3.11 N/Kg (terminal node 3), had an increased likelihood of having AKP (PR of 2.44). In other words, they had 144% more likelihood of having AKP. Excessive hip joint stiffness, as shown in our results, may limit lower limb IR and foot pronation, compromising absorption and dissipation of mechanical energy.[59,60] As consequence, part of the energy that should be dissipated elsewhere in the lower extremity would be transferred to other structures, such as the knee joint, predisposing them to injury.[59,61,62]

On the other hand, cyclists with passive hip IR ROM above 15º, associated with lower than 46.7º of ankle dorsiflexion ROM (terminal node 5), had 64% less likelihood of having AKP (PR of 0.36). It has already been shown that low hip stiffness in the transverse plane may result in excessive amount and/or duration of hip IR and foot pronation during the stance phase of gait,[59] which were associated with AKP.[63,64] Therefore, the tissues surrounding the hip joint must have adequate stiffness to generate appropriate resistance to IR. Bittencourt et al[30] could somehow show this role of the hip passive IR ROM. When hip passive IR ROM was greater than 43º or among 43º and 37º associated with less hip abductor torque, participants exhibited more chance to present frontal plane knee projection angle during squatting. Interestingly, our results showed the opposite role for passive hip stiffness, which was reduced (lower than 15º) in the absence of AKP. Moroever, our cut-off values for passive hip IR ROM were quite lower (15º) which could be explained, speculatively, by a higher frequency of femur retroversion (15-20º)[65] among mountain bikers. Future studies should then take into consideration femoral torsion when investigating AKP in cyclists.

AKP occurrence could be accurately identified in 12 participants (node 3) when hip passive IR ROM lower than 15º in association with values lower than 3.11 N/Kg for hip posterolateral muscle strength. The ability to maintain adequate alignment of the lower limbs depends on strength and proper activation of the hip abductor, external rotator, and extensor muscles.[66-68] Weaknesses of these muscles are found in AKP.[39,69,70] In order to evaluate hip strength, HipSIT was used because it is a reliable and a valid test for assessing hip stabilizing muscles.[52] Besides, it is a more practical test and could be used in the clinical setting helping clinicians to save time with assessment. However, this test evaluates three hip muscle groups concurrently and a specific deficit in one muscle group could not be possible to detect. Also, several studies, such as Bittencourt et al[30] and Mendonca et al,[34] use muscle torque to check for hip muscle capacity. In contrast, HipSIT provides values for strength, which are then normalized with body weight (N/Kg). That makes our results relative to hip muscle capacity less comparable to others, which could also be considered a limitation of this study. Further studies analyzing isolated muscle strength of hip muscles and their relationship to AKP in mountain bikers should be done in the future.

Absence of AKP could be accurately identified in 15 cyclists (node 5) when hip passive IR ROM was higher than 15º in association with values lower than 46.7º of ankle dorsiflexion ROM (terminal node 6; PR of 1.33). Interestingly, that contradicts studies conducted with athletes of other sports modalities. For example, basketball players with dorsiflexion range less than 36.5º had a risk of 18.5% to 29.4% of developing AKP within a year, as compared with 1.8% to 2.1% for players with dorsiflexion range greater than 36.5º.[28] Moreover, having less than 45º of ankle dorsiflexion range increased the risk of AKP by 1.8-2.8 times in volleyball players.[29] To our knowledge, this is the first study assessing ankle dorsiflexion ROM in cyclists and no directly comparable values are available in the literature. However, besides the great variability of movement pattern in the ankle joint, mountain bike cyclists exhibited more plantarflexion during the pedaling cycle than road cyclists.[71] That could offer an overview about the amount of ankle range of motion necessary to perform the pedal revolution in mountain biking. Additionally, we speculate that ankle joint should work as a more rigid link during cycling which is more likely to occur in a plantarflexed position. While pedaling, energy produced by knee and hip extensors cannot be delivered directly to the bicycle crank because an effective propulsive force (tangential crank force) cannot be directly generated by them.[72] Nevertheless, a tangential crank force is instead largely produced by plantar flexors. An extensor synergy happens tough, enabling work output of the energy producing muscles to be delivered to the crank.[72] Hence, it could be possible that the less dorsiflexion a mountain biker exhibits during pedaling, the less chance of AKP is present probably because of this energy transfer role played by plantar flexors, which prevents energy concentration on knee tissues that could lead to pain complaints.[59]

Foot Alignment

Lower values of passive hip IR ROM (≤15º), in association with higher values of HipSIT (> 3.11 N/Kg) and lower values of SFA (≤ 0.5º) were linked to the presence of AKP (terminal node 7). On the other hand, lower values of passive hip IR ROM (≤15º), in association with higher values of HipSIT (> 3.11 N/Kg) and higher values of SFA (>0.5º) were linked to the absence of AKP (terminal node 8; PR of 0.25). Foot misalignments have been indicated as a risk factor for AKP.[74] Increased foot varus generates excessive foot pronation and makes the foot complex flexible in excess to work as a stiff lever for energy transfer during propulsion. That may alter movement pattern necessary to produce proper sport gesture,[75] which, if repetitively performed, may result in excessive knee joint stress. Our results are in accordance to this rationale, since AKP absence was related to higher passive hip joint stiffness associated to higher levels of hip muscle strength and lower values of varus SFA. However, cut-off point for this predictor was very low (0.5º). As a matter of comparison, Mendonça et al[56] established normative data of 13.9º for SFA in athletes of various sports modalities (cycling was not included). In addition, all participants in terminal node 7 (n=4) exhibited SFA valgus, which could be responsible for the lower cut-off values observed. Anywise, it is important to mention that these relationships among the variables (nodes 6, 7, and 8) could not reach statistical significance on prevalence ratio.

Limitations

Since this was a cross-sectional study, it is not advisable to extrapolate our results to the general mountain bike population specially in terms of the cut-off values, which are sample-dependent. Also, causal relationships cannot be established. To determine that, prospective investigations are required. Moreover, interactions among other variables not investigated on this study may be present in the occurrence of AKP, including behavioral and physiological factors, as well as cycling kinematics was not investigated in this study and should be considered in the future since they are thought to play an important role in cycling related injuries.[8,76] Those aspects should then be explored in future studies. The interpretation that the interaction between low passive hip stiffness and increased ankle dorsiflexion ROM as well as low hip passive stiffness, weakness of hip muscles and ankle-foot alignment may contribute to AKP occurrence should be made with caution. That could be derived from some sample profile specificities or even to the limited sample size (n=50).

Interactions Among Variables

Finally, non-linear and complex interactions between predictors and the outcome were revealed by our results. Moreover, risk and protective profiles related to AKP occurrence or absence in mountain bikers were identified. The contribution of each variable in isolation to the outcome (e.g. passive hip IR ROM) was only possible in the presence of other variables (e.g. HipSIT and ankle dorsiflexion ROM). That could assist clinical practice as clinicians could select interventions based on the individual profile established by CART final nodes, focusing on modifying these factors. In addition, preventive programs could be planned based on achieving proper hip IR ROM (above 15º) and high hip strength (above 3.11 N/kg), since athletes with this profile had increased likelihood of not having AKP.

CONCLUSION

The occurrence of AKP in mountain bike cyclists was associated with an interaction among passive hip IR ROM, HipSIT and ankle dorsiflexion ROM. CART analysis captured nonlinear and complex interactions among those variables, indicating that the contribution of one factor depends on the presence of other factors. As such, passive hip IR ROM, strength of posterolateral hip muscles and ankle dorsiflexion ROM could be considered as predictors for AKP. Then, those aspects should be taken into consideration when managing AKP in mountain bikers.

SUMMARY BOX

- AKP occurrence in mountain bike cyclists was associated with an interaction among passive hip IR ROM, HipSIT and ankle dorsiflexion ROM.
- Passive hip IR ROM, HipSIT and ankle dorsiflexion ROM exhibited nonlinear and complex interactions, indicating that the contribution of one factor depends on the presence of other factors.
- Passive hip IR ROM, strength of posterolateral hip muscles and ankle dorsiflexion ROM can be considered as predictors for AKP.
- When managing AKP in mountain bikers, passive hip IR ROM, strength of posterolateral hip muscles and ankle dorsiflexion ROM should be taken into consideration.

TABLES

Table 1 Reliability of the clinical variables

	$ICC_{3,3}$	SE	95% CI
Ankle dorsiflexion ROM	0.87	2.78	0.62-0.95
Bridge test KE	0.86	0.67	0.63-0.95
Passive hip IR ROM	0.95	3.50	0.87-0.98
HipSIT	0.92	21.39	0.79-0.97
SFA	0.86	2.30	0.62-0.95

ICC, intraclass correlation coefficient; SE, standard error; CI, confidence interval; ROM, range of motion; KE, knee extension; HipSIT, hip stability isometric test; SFA, shank-forefoot alignment.

Table 2 Comparison of mean (SD) anthropometric features, questionaries' scores, clinical variables and training characteristics of participants (α = 0.05)

	Total (n=50)		AKP group (n=26)	No AKP group (n=24)	Group comparison test
	Mean (SD)	Min-Max	Mean (SD)	Mean (SD)	p Value
Age (years)	37.1 (6.77)	21-56	35.54 (5.64)	38.79 (7.58)	0.090
Hight (meters)	1.74 (0.08)	1.55-1.89	1.75 (0.07)	1.74 (0.08)	0.599
Weight (kilos)	75.42 (14.30)	50-118	76.59 (12.02)	74.14 (16.59)	0.550
AKPS (points)	89.20 (10.24)	62-100	83.77 (10.41)	95.08 (6.06)	0.0001*
VISA-P (points)	88.08 (12.89)	46-100	81.03 (14.04)	95.71 (4.82)	0.0001*
PSFS (points)	8.46 (2.12)	3-10	7.15 (2.22)	9.88 (0.45)	0.0001*
ADROM (degrees)	43.91 (0.72)	32.30-55.00	44.55 (5.48)	43.22 (4.56)	0.352
BTKE (degrees)	5.38 (2.51)	0.30-11.30	6.02 (2.23)	4.67 (2.65)	0.059
SFA (degrees)	13.36 (9.75)	-4.00-40.10	12.46 (10.31)	14.34 (9.22)	0.499
PHIROM (degrees)	18.79 (11.52)	1.70-50.30	16.57 (11.66)	21.19 (11.10)	0.068¤
HipSIT (N/Kg)	2.80 (0.83)	1.36-4.88	1.36 (4.13)	1.42 (4.88)	0.523
Time of sports practice (years)	8.04 (6.48)	1-30	7.54 (6.95)	8.58 (6.03)	0.292
Time in elite sports (years)	2.08 (3.66)	0-15	3.15 (4.55)	0.92 (1.86)	0.024*
Week training frequency	3.76 (1.31)	1-6	4.00 (1.41)	3.50 (1.18)	0.155
Mean training duration (minutes)	137.04 (33.21)	90-240	145.08 (36.20)	128.33 (27.81)	0.094
Mean training distance (Km)	42.53 (10.49)	24-65	42.25 (10.13)	42.83 (11.08)	0.847
Longest training duration in 2017 (hours)	6.45 (2.12)	2-13	6.72 (2.17)	6.17 (2.08)	0.304
Longest training distance in 2017 (Km)	122.43 (45.69)	49-280	125.00 (52.79)	119.64 (37.43)	0.683
Race participation in 2017 (days)	6.76 (8.16)	0-30	7.84 (7.09)	5.58 (9.18)	0.108

SD, standard deviation; min; Minimum; Max, maximum; ADROM, ankle dorsiflexion range of motion; BTKE, bridge test with unilateral knee extension; SFA, shank-forefoot alignment; PHIROM, passive hip internal rotation range of motion; HipSIT, hip stability isometric test.

*p ≤0.05 ¤calculated using Student t test or Mann-Whitney U test

Table 3 Prevalence ratio of each terminal node of CART model

Terminal node	PR (95% CI)
Node 3	2..44 (1.57-3.79)*
Node 5	0.36 (0.16-0.79)*
Node 6	1.33 (0.70-2.52)
Node 7	-
Node 8	0.25 (0.04-1.54)

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FIGURES

Figure 1 – Assessment of ankle dorsiflexion range of motion

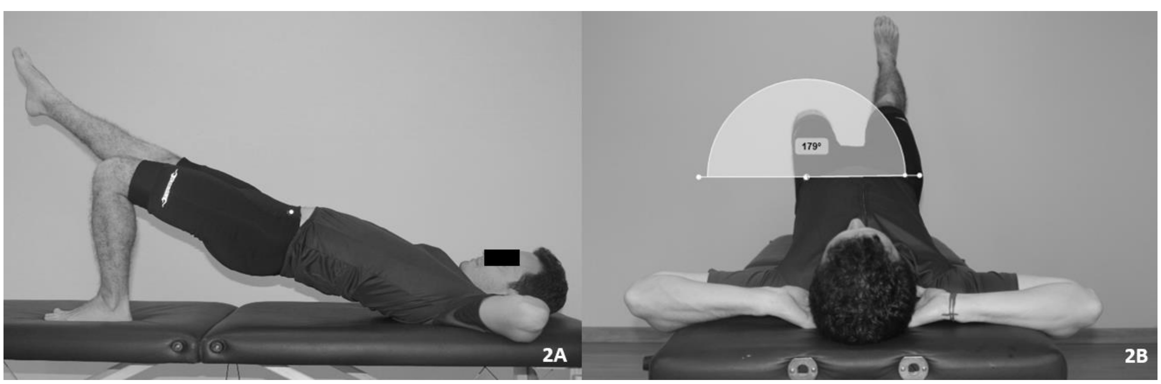


Figure 2 – Bridge test with unilateral knee extension

Figure 3 – Assessment of passive hip internal rotation range of motion

Figure 4 – Hip stability isometric test (HipSIT)

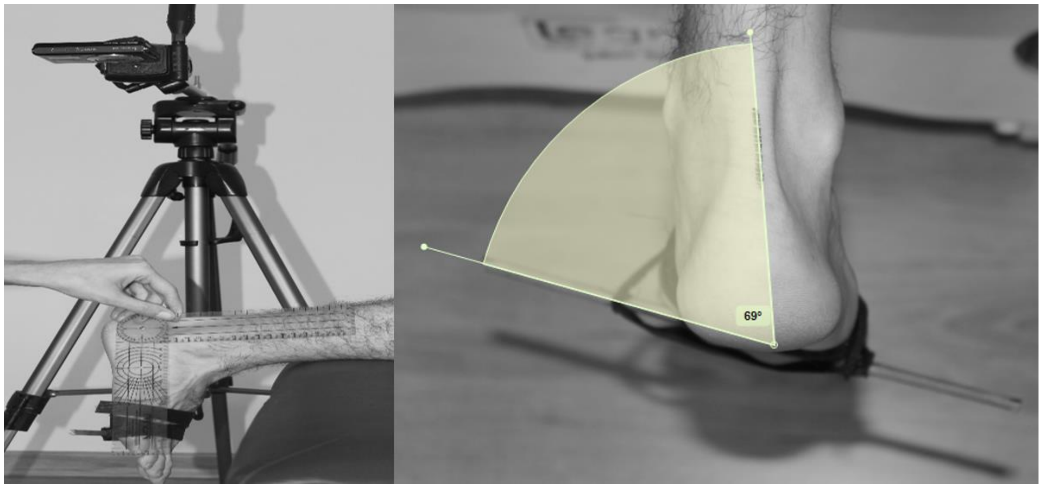


Figure 5 – Shank forefoot alignment (SFA) measurement

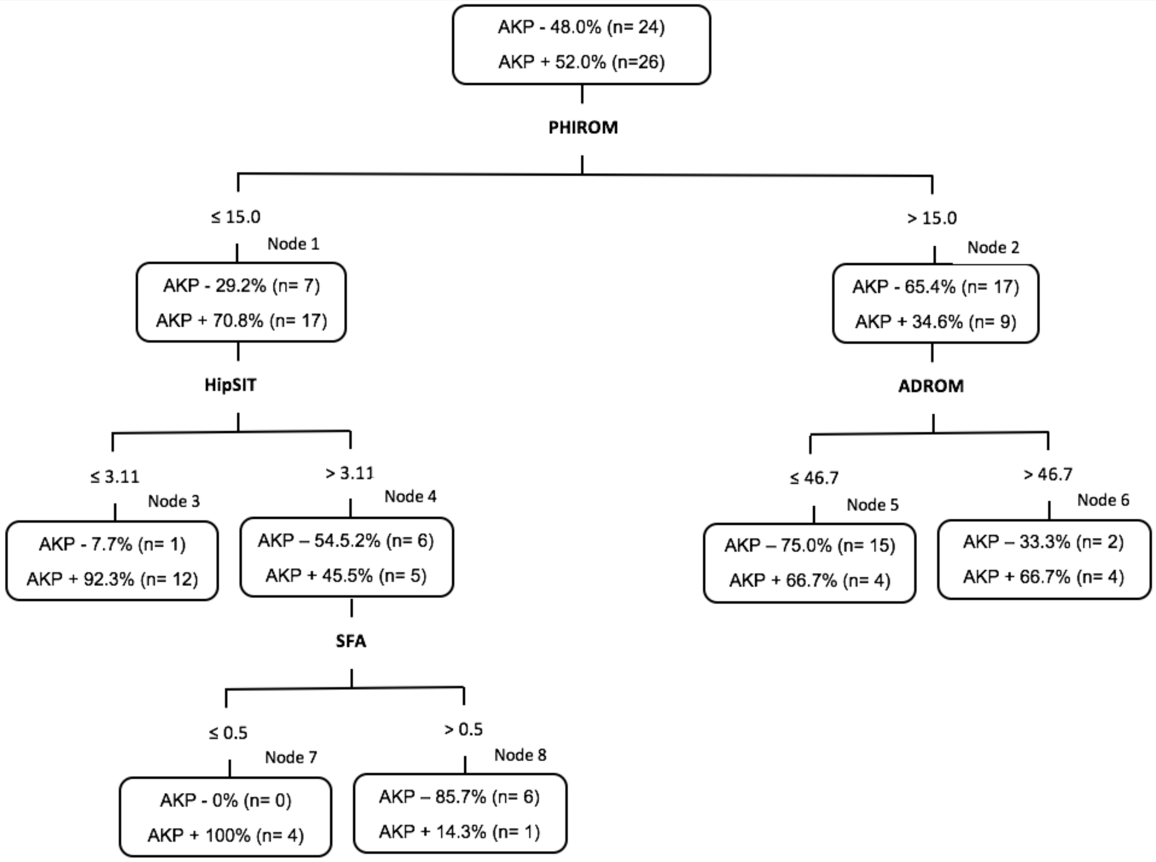


Figure 6 Classification tree model for anterior knee pain. Bolded text in each node (AKP + or AKP -) corresponds to the predicted category. Significant classification profile for the presence of AKP in terminal node 3 was: PHIROM under 15.0° and HipSIT less than 3.11 N/Kg. Significant classification profile for the absence of AKP in terminal node 5 was PHIROM above 15.0° and ADROM under 46.7°. Abbreviations: AKP (anterior knee pain), PHIROM (passive hip internal rotation range of motion), HipSIT (Hip Stability Isometric Test), ADROM (ankle dorsiflexion range of motion), SFA (shank-forefoot alignment).

6. CONSIDERAÇÕES FINAIS

A presente dissertação buscou investigar a associação entre fatores musculoesqueléticos e de posicionamento sobre a bicicleta com a ocorrência de DAJ em ciclistas de *mountain bike*. Para tanto, dois estudos foram realizados.

O Estudo 1 foi planejado para verificar a associação entre as variáveis cinemáticas do ciclista ao pedalar com a ocorrência de DAJ nestes ciclistas por meio de regressão logística. Durante a pedalada, flexão plantar, flexão e extensão máximas de joelho e inclinação de tronco foram capazes de predizer DAJ nesta população, ao passo que alinhamento entre quadril, joelho e tornozelo-pé no plano frontal não foram capazes. Ou seja, foi possível a identificação das posições dinâmicas de tronco e de membros inferiores no plano sagital sobre a bicicleta como preditores de DAJ.

O Estudo 2 foi desenvolvido para investigar as interações entre fatores musculoesqueléticos relacionados ao tronco, ao quadril e ao complexo tornozelo-pé associadas com a ocorrência de dor anterior no joelho em *mountain bikers* por meio da análise da CART. Interações entre amplitude de movimento passiva de rotação medial do quadril, força da musculatura póstero-lateral do quadril, amplitude de movimento de dorsiflexão do tornozelo e alinhamento perna-antepé identificaram *mountain bikers* com e sem dor anterior no joelho. Vale ressaltar que nenhuma das variáveis isoladamente foi capaz de predizer o desfecho, o que significa que a ocorrência ou a ausência de DAJ foram baseadas na associação de preditores. Assim, perfis de risco e de proteção para DAJ puderam ser identificados.

Os resultados da presente dissertação revelaram a participação de fatores musculoesqueléticos e de posicionamento do ciclista sobre a bicicleta relacionados à DAJ em ciclistas de *mountain bike*. Assim, clinicamente, os profissionais do esporte diretamente relacionados com o tratamento de atletas lesionados ou com a prevenção de lesões nestes ciclistas necessitam analisar e levar em consideração seu posicionamento dinâmico sobre a bicicleta e as interações identificadas entre os fatores musculoesqueléticos.

APÊNDICE A – TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO

MINISTÉRIO DA EDUCAÇÃO

Universidade Federal dos Vales do Jequitinhonha e Mucuri

Comitê de Ética em Pesquisa

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO (TCLE)

Você está sendo convidado (a) a participar de uma pesquisa intitulada: **"IDENTIFICAÇÃO DO PERFIL DE RISCO PARA DOR ANTERIOR NO JOELHO EM CICLISTAS DE MOUNTAIN BIKE"**, coordenada pela Professora Luciana De Michelis Mendonça e conduzida pelo aluno de mestrado Guilherme Ribeiro Branco.

Seu convite está sendo feito por você ser atleta federado de *mountain bike* do estado de Minas Gerais, ter idade acima de 18 anos, não ter realizado tratamento fisioterápico e/ou procedimento cirúrgico na coluna e/ou nos membros inferiores nos últimos 12 meses, não apresentar sinais ou sintomas graves de dor lombar ou dor anterior no joelho e não ser para-atleta. Seu contato foi disponibilizado pela Federação Mineira de Ciclismo, que é parceira no desenvolvimento desse estudo.

O objetivo principal desta pesquisa é identificar os perfis de risco associados à ocorrência de dor anterior no joelho em ciclistas de *mountain bike*.

Caso você decida aceitar o convite, será submetido(a) aos seguintes procedimentos: resposta de quatro (04) questionários; conferência de (1) alinhamento dos pés, (2) quantidade de movimento nas articulações dos quadris e dos tornozelos (3) força muscular de quadris, (4) teste de desempenho para a estabilidade da região lombo-pélvica (5) posicionamento sobre sua bicicleta. Todos os procedimentos acima citados serão realizados em local reservado, onde somente estarão presentes você e o pesquisador responsável pela condução dos procedimentos. O tempo previsto para a sua participação é de aproximadamente duas horas.

Ao preencher o questionário, você não será exposto(a) a riscos para sua saúde, porém, pode haver algum constrangimento para responder a algumas perguntas. Caso isso ocorra, você poderá

Assinatura do participante: ________________________

Assinatura do pesquisador responsável: ________________________

se negar a respondê-las, sem nenhum prejuízo a você ou à sua participação no estudo. Vale ressaltar que será assegurada total confidencialidade das informações fornecidas e o sigilo de sua identidade, as quais serão de conhecimento somente dos pesquisadores e utilizadas apenas para os fins da pesquisa em questão. Ainda, o preenchimento do questionário ocorrerá em local escolhido por você, seja na presença ou na ausência do pesquisador envolvido com o projeto.

Já para a realização dos outros procedimentos, todo o processo ocorrerá em um espaço privativo e preparado para tanto e você não estará exposto(a) a terceiros, podendo contar com a reserva e com a discrição de que necessita. Para os testes de força muscular de quadris e teste de desempenho para a estabilidade da região lombo-pélvica, os riscos relacionados são aqueles comumente associados à prática de atividade física, tais como cansaço, falta de ar, tontura e dores musculares e articulares após o exercício. Para os testes de conferência de (1) alinhamento dos pés, (2) quantidade de das articulações dos tornozelos e dos quadris, os riscos se referem à impossibilidade e o inconveniente de assumir e manter as posições e realizar os movimentos requeridos para cada um dos procedimentos. Essas situações são raras e o participante será acompanhado todo o tempo por um profissional treinado. Qualquer desconforto durante e após os procedimentos deverão ser imediatamente informados aos pesquisadores para que estes possam tomar as providências imediatas devidas (interrupção do procedimento, realização de primeiros socorros e encaminhamento a pronto atendimento, caso necessário). Finalmente, para verificação de seu posicionamento sobre sua bicicleta, os riscos relacionados dizem respeito à possibilidade de queda ao subir e/ou descer da bicicleta, bem como pela possibilidade de desenvolvimento de reações alérgicas cutâneas causadas pelo adesivo dos eletrodos do sistema de análise de movimento, que serão fixados diretamente sobre a sua pele. Novamente, essas situações são raras e você será acompanhado(a) e auxiliado(a) todo o tempo por profissionais treinados. Qualquer desconforto e/ou irritações cutâneas durante e após os procedimentos deverão ser imediatamente informados aos pesquisadores para que estes possam tomar as providências imediatas devidas. Ainda, durante a subida e a descida da bicicleta, você será auxiliado(a) pelo pesquisador, de modo a reduzir os riscos de queda.

Os benefícios decorrentes da sua participação nesta pesquisa serão diretos e indiretos por meio da obtenção de informações detalhadas sobre suas condições musculoesqueléticas, sendo possível identificar possíveis fatores que possam auxiliar ou comprometer sua saúde e, consequentemente, a prática de sua atividade esportiva. Ao final de sua participação, você receberá um relatório completo e detalhado, incluindo sugestões para controle das possíveis alterações encontradas nos testes ou encaminhamento a serviços especializados, caso necessário. Além disso, os resultados da pesquisa contribuirão para maior compreensão sobre o perfil de risco na ocorrência de dor anterior no joelho em ciclistas de *mountain bike*. Desse modo, será possível o desenvolvimento de

Assinatura do participante: ________________________

Assinatura do pesquisador responsável: ________________________

possíveis estratégias de prevenção dessas lesões, o que, consequentemente, tornará a prática do esporte mais segura e saudável.

Para os testes, você deverá trazer consigo roupas de prática de ciclismo (bermuda ou bretele, camiseta e sapatilhas) e sua bicicleta. É importante que você evite prática de atividade extenuante e de longa duração nas 24 horas antecedentes ao teste.

Os resultados desta pesquisa poderão ser apresentados em eventos científicos como seminário e congressos, por exemplo, e também poderão ser publicados em revistas cientificas. Entretanto, os dados e as informações obtidos por meio da sua participação serão confidenciais e sigilosos, não possibilitando sua identificação.

A sua participação bem como a de todas as partes envolvidas será voluntária. Não haverá remuneração dos participantes, bem como não está prevista indenização para a participação no estudo, mas, se em qualquer momento você sofrer algum dano, comprovadamente decorrente desta pesquisa, a indenização será efetuada.

A sua participação não é obrigatória sendo que, a qualquer momento da pesquisa, você poderá desistir e retirar seu consentimento. Sua recusa não trará nenhum prejuízo para sua relação com o pesquisador ou com as instituições participantes do projeto.

Você receberá uma cópia deste termo no qual constam o telefone e o endereço do pesquisador principal, podendo tirar suas dúvidas sobre o projeto e sobre sua participação agora ou em qualquer momento.

Coordenadora do Projeto: Professora Dra. Luciana De Michelis Mendonça
Endereço: Rodovia MGT 367 - Km 583 - nº 5000 - Alto da Jacuba, Diamantina/MG
CEP39100000
Telefone: (38) 3532-1239 / (31) 98888-2945

Declaro que entendi os objetivos, a forma de minha participação, riscos e benefícios da mesma e aceito o convite para participar. Autorizo a publicação dos resultados da pesquisa, a qual garante o anonimato e o sigilo referente à minha participação.

Nome do participante: ___________________________________
Assinatura do participante: _________________________
Assinatura do pesquisador responsável: _________________________

Informações – Comitê de Ética em Pesquisa da UFVJM
Rodovia MGT 367 - Km 583 - nº 5000 - Alto da Jacuba –
Diamantina/MG CEP39100000
Tel.: (38)3532-1240 –
Coordenador: Prof. Disney Oliver Sivieri Junior
Secretaria: Ana Flávia de Abreu
Email: cep.secretaria@ufvjm.edu.br e/ou cep@ufvjm.edu.br

APÊNDICE B – PERFIL DO CICLISTA

MINISTÉRIO DA EDUCAÇÃO

Universidade Federal dos Vales do Jequitinhonha e Mucuri

Comitê de Ética em Pesquisa

PERFIL DO CICLISTA

INFORMAÇÕES GERAIS

Nome:____

Código de identificação:__________ **Idade**: _______ **Data de Nascimento**: ____/____/______

Peso: ______ **Estatura**: ______ **IMC**:_______ **Membro dominante**:______ (D/E/A)

Escolaridade do pai: _________________ **Escolaridade da Mãe**: _________________

Escolaridade do atleta: _________________

Há quantos anos você pratica a modalidade? _______________________________________

Há quanto tempo compete no alto rendimento? _______________ (anos)

Histórico de cirurgia(s)?

SIM (   ) **Qual?** _________________________ **Quando foi realizada?** ________________

NÃO (   )

Possui algum problema de saúde?

SIM (   ) **Qual?** ____________________________ NÃO (   )

Já teve alguma doença pulmonar, cardiovascular ou metabólica?

SIM (   ) **Qual?** ____________________________ NÃO (   )

Tem alguma doença pulmonar, cardiovascular ou metabólica?

SIM (   ) **Qual?** ____________________________ NÃO (   )

Uso de medicamento?

SIM (   ) **Qual?** ____________________________ NÃO (   )

Pratica outras modalidades esportivas?

SIM ( ) **Qual? ___________________ Com que frequência semanal? _________________**

NÃO ( )

Trocou de técnico/treinador em 2016?

SIM ( ) **Quantas vezes? ___________________** NÃO ( )

Trocou de técnico/treinador em 2017?

SIM ( ) Quantas vezes? ___________________ NÃO ( )

Realizou bike fit na bicicleta utilizada em 2016?

( ) SIM ( ) NÃO

Em qual bike? ( ) Treino (MTB)

( ) Treino (ROAD/SPEED)

( ) Competição

Qual tipo de bike fit?

( ) Estático (medidas com o ciclista parado em pontos específicos da pedalada)

( ) Dinâmico (medidas durante a pedalada sem o ciclista parar)

Realizou bike fit na sua bicicleta atual?

SIM ( ) Qual (de treino/ de competições/ambas)? ____________________ NÃO ( )

Qual tipo de bike fit?

( ) Estático (medidas com o ciclista parado em pontos específicos da pedalada)

( ) Dinâmico (medidas durante a pedalada sem o ciclista parar)

Quantas sessões de treino realiza por semana? ___________

Duração da sessão (minutos): ______________

Distância percorrida média percorrida por sessão: ______________ (quilômetros)

Usa algum tipo de medição durante seus treinamentos?

( ) SIM ( ) NÃO

Que tipo? ( ) Frequência cardíaca

( ) Potência

( ) Percepção de esforço

( ) Outros: __________________________ (favor especificar)

Quantos dias de competição você teve na temporada de 2016? ______________________

Isto é baseado em diário/registro de treinos?

( ) SIM ( ) NÃO, É UMA ESTIMATIVA

Quantos dias de treino você teve na temporada de 2016? ______________________

Isto é baseado em diário/registro de treinos? ( ) SIM ( ) NÃO, É UMA ESTIMATIVA

Quantos dias de competição você teve na temporada de 2016? ______________________

Isto é baseado em diário/registro de treinos?

( ) SIM ( ) NÃO, É UMA ESTIMATIVA

Quantos dias de treino você teve na temporada de 2017? ______________________

Isto é baseado em diário/registro de treinos? ( ) SIM ( ) NÃO, É UMA ESTIMATIVA

Quantos dias de competição você teve na temporada de 2017? ______________________

Isto é baseado em diário/registro de treinos?

( ) SIM ( ) NÃO, É UMA ESTIMATIVA

Você realizou treino de flexibilidade em algum momento na temporada de 2016?

( ) SIM ( ) NÃO

Em que momentos? ( ) Fora da temporada

( ) Pré-temporada

( ) Início da temporada

( ) Pico da temporada

( ) Final da temporada

Você realizou treino com pesos em algum momento na temporada de 2016?

( ) SIM ( ) NÃO

Em que momentos? ( ) Fora da temporada

( ) Pré-temporada

( ) Início da temporada

( ) Pico da temporada

( ) Final da temporada

Você realizou treino de força na bicicleta em algum momento na temporada de 2016?

( ) SIM ( ) NÃO

Em que momentos? ( ) Fora da temporada

( ) Pré-temporada

( ) Início da temporada

( ) Pico da temporada

( ) Final da temporada

Qual cadência você geralmente usou neste tipo de treino? ( ) menor que 40 rpm

( ) 40 a 50 rpm

( ) 50 a 60 rpm

( ) maior que 60 rpm

Você está realizando algum programa individualizado de exercícios especificamente para prevenir lesões em algum momento da temporada de 2017?

( ) SIM ( ) NÃO

Em que momentos? ( ) Fora da temporada

( ) Pré-temporada

( ) Início da temporada

( ) Pico da temporada

( ) Final da temporada

Você está realizando treino de flexibilidade em algum momento na temporada de 2017?

( ) SIM ( ) NÃO

Em que momentos? ( ) Fora da temporada

( ) Pré-temporada

( ) Início da temporada

( ) Pico da temporada

( ) Final da temporada

Você está realizando treino com pesos em algum momento na temporada de 2017?

( ) SIM ( ) NÃO

Em que momentos? ( ) Fora da temporada

( ) Pré-temporada

( ) Início da temporada

( ) Pico da temporada

( ) Final da temporada

Você está realizando treino de força na bicicleta em algum momento na temporada de 2017?

( ) SIM ( ) NÃO

Em que momentos? ( ) Fora da temporada

( ) Pré-temporada

( ) Início da temporada

( ) Pico da temporada

( ) Final da temporada

Qual cadência você geralmente usou neste tipo de treino? ( ) menor que 40 rpm

( ) 40 a 50 rpm

( ) 50 a 60 rpm

( ) maior que 60 rpm

Você está realizando algum programa individualizado de exercícios especificamente para prevenir lesões em algum momento da temporada de 2017?

( ) SIM ( ) NÃO

Em que momentos? ( ) Fora da temporada

( ) Pré-temporada

( ) Início da temporada

( ) Pico da temporada

( ) Final da temporada

Você utiliza pedais com tacos fixos (não permite qualquer movimentação do pé quando a sapatilha está encaixada no pedal)?

( ) SIM ( ) NÃO

Em qual bike? ( ) Treino (MTB)

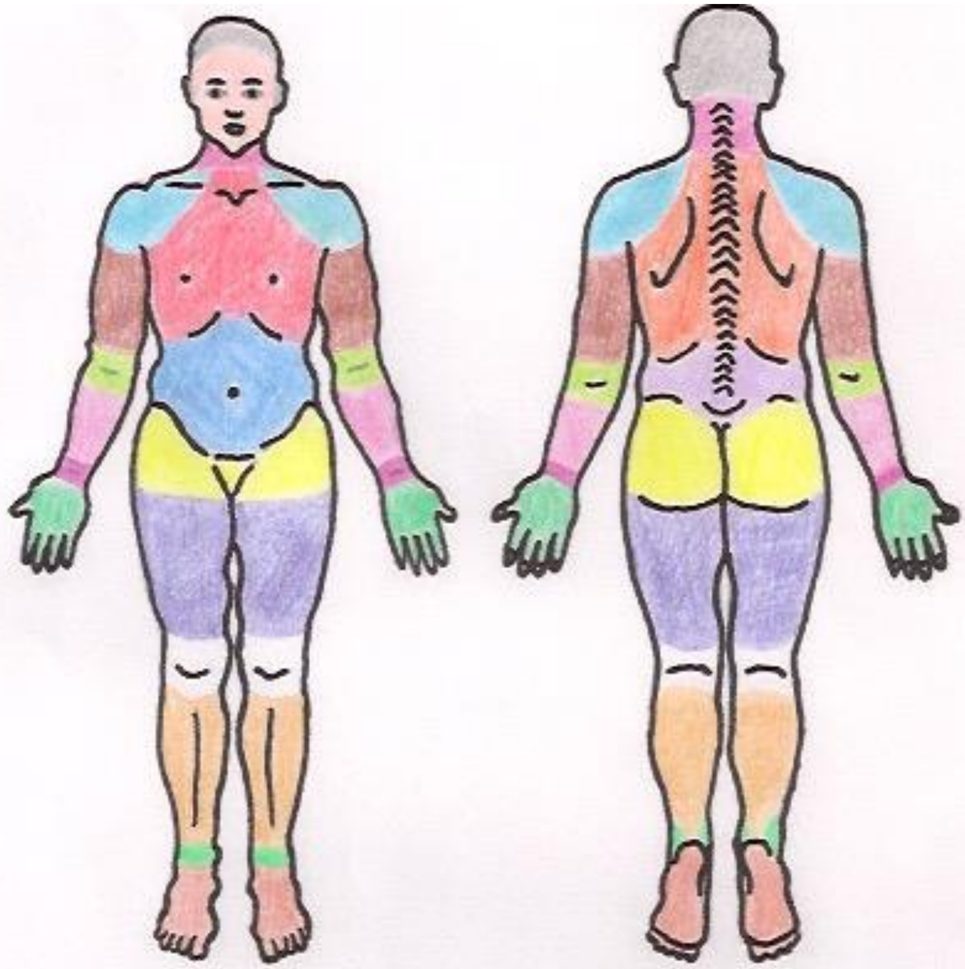
( ) Treino (ROAD/SPEED)

( ) Competição

INFORMAÇÕES SOBRE LESÕES

Para preenchimento dessa seção, deve-se considerar como lesão qualquer dor ou desconforto que não estejam diretamente relacionados a um evento traumático (queda da bike, pancada, torção, por exemplo). Essa dor ou desconforto afeta sua habilidade em competições ou treinos OU faz com que procure assistência por um profissional de saúde qualificado (considerar ambas as situações).

Para descrição do local de lesão, utilizaremos o diagrama abaixo e as definições a seguir:



cabeça (1)

face (2)

pescoço/cervical (3)

ombro/clavícula (4)

esterno/costela (5)

costas (6)

abdômen (7)

lombar/sacro/pelve (8)

braço (9)

cotovelo (10)

antebraço (11)

punho (12)

mão/dedo/polegar (13)

quadril (14)

coxa (15)

joelho (16)

perna/tendão de Aquiles (17)

tornozelo (18)

pé/dedos do pé (19)

A partir de agora, para cada lesão informada, descreva:

Teve em mantém alguma lesão na temporada de 2016? ( ) SIM ( ) NÃO

Em que local (enumere de 1 a 19 conforme o diagrama acima): ________________________________

Quando essa lesão ocorreu pela primeira vez? Para te auxiliar, confira os calendários de provas de 2016 em anexo.

Essa lesão ocorreu mais de uma vez (especifique o local ______)? ( ) SIM ( ) NÃO

Quando ocorreu nos últimos 12 meses? ______________

Em que situação? ( ) treino

( )competição

( ) ambos

Você recebeu tratamento para essa lesão (especifique o local ______)?

( ) SIM ( ) NÃO

Por qual profissional? ( ) Fisioterapeuta

( ) Médico

( ) Massagista

( ) Outro: ___________________ (especifique, por favor)

( ) Não tem certeza

Como essa lesão afetou seu desempenho na prática do MTB (selecione a opção que descreva o pior estado da lesão)? ( ) Era capaz de treinar ou competir (especifique o local __________)

( ) Era capaz de completar treinos e competições, mas com desempenho reduzido (especifique o local __________)

( ) Foi necessário reduzir a carga de treinamento (especifique o local __________)

( ) Não era possível treinar e nem competir(especifique o local __________)

(   ) Tive que abandonar a prática do esporte (especifique o local __________)

A que fatores você atribui o desenvolvimento dessa lesão?

(   ) Muito treinamento ou competições (especifique o local __________)

(   ) Pouco treinamento (especifique o local __________)

(   ) Treinamento fora da bike (especifique o local __________)

(   ) Equipamento (especifique o local __________)

(   ) Posicionamento na bike (especifique o local __________)

(   ) Fraqueza muscular específica (especifique o local __________)

(   ) Outro: ____________________________ (especifique, por favor)

Teve em mantém alguma lesão na temporada de 2017? (   ) SIM (   ) NÃO

Em que local (enumere de 1 a 19 conforme o diagrama acima): __________________________________

Quando essa lesão ocorreu pela primeira vez? Para te auxiliar, confira os calendários de provas de 2017 em anexo.

Essa lesão ocorreu mais de uma vez (especifique o local ______)? (   ) SIM (   ) NÃO

Quando ocorreu nos últimos 12 meses? ______________

Em que situação? (   ) treino

(   )competição

(   ) ambos

Você recebeu tratamento para essa lesão (especifique o local ______)?

(   ) SIM (   ) NÃO

Por qual profissional? (   ) Fisioterapeuta

(   ) Médico

(   ) Massagista

(   ) Outro: ___________________ (especifique, por favor)

(   ) Não tem certeza

Como essa lesão afetou seu desempenho na prática do MTB (selecione a opção que descreva o pior estado da lesão)? (   ) Era capaz de treinar ou competir (especifique o local __________)

(   ) Era capaz de completar treinos e competições, mas com desempenho reduzido (especifique o local __________)

(   ) Foi necessário reduzir a carga de treinamento (especifique o local __________)

(   ) Não era possível treinar e nem competir(especifique o local __________)

(   ) Tive que abandonar a prática do esporte (especifique o local __________)

A que fatores você atribui o desenvolvimento dessa lesão?

(   ) Muito treinamento ou competições (especifique o local __________)

(   ) Pouco treinamento (especifique o local __________)

(   ) Treinamento fora da bike (especifique o local __________)

(   ) Equipamento (especifique o local __________)

(   ) Posicionamento na bike (especifique o local __________)

(   ) Fraqueza muscular específica (especifique o local __________)

(   ) Outro: ____________________________ (especifique, por favor)

CALENDÁRIO DE PROVAS 2016 - FEDERAÇÃO MINEIRA DE CICLISMO

JANEIRO 2016

24 - 1º DESAFIO DE MOUNTAIN BIKE SANTA HELENA

30 - COPA MAXXIS DE XCO BY RAVELLI - XCO

31 - COPA MAXXIS DE XCO BY RAVELLI - XCM

31 - INTECITY ONÇA DO PITANGUI

31 - 4° COPA MINAS DE MOUNTAIN BIKE 2016 #1

FEVEREIRO 2016

14 - 1° PASSEIO CICLÍSTICO LAPA BIKE 2016

21 - COPA GRANDE SERTÃO #1

21 - 4° COPA MINAS DE MOUNTAIN BIKE 2016

28 - 1° DESAFIO DE MTB CIDADE DE PIRACEMA

28 - SUPER MOUNTAIN BIKE XCO

28 - UP HILL DE MARIANA

MARÇO 2016

04 a 06 - CIMTB - COPA INTERNACIONAL DE MTB

13 - DESAFIO MOUNTAIN BIKE #1

13 - CIPÓ BIKE

13 - COPA PEDAL MINEIRO DE MOUNTAIN BIKE # 1

13 - BIKE RACE BRASIL MTB 2016

20 - COPA BIG MAIS MTB #1

20 - XTERRA 2016

ABRIL 2016

3 - DESAFIO FOR RIDE DE MOUNTAIN BIKE

10 - CAMPEONATO MINEIRO DE MARATONA 2016 #1

17 - MARATHON CUP MTB #1

17 - BIKE ENDURO DE MARIANA

24 - 3° DESAFIO ARCOS DE MOUNTAIN BIKE

24 - COPA PEDAL MINEIRO DE MOUNTAIN BIKE # 2

30 - DESAFIO EXTREMO ESTRADA REAL

MAIO 2016

1 - III COPA MINAS DE MOUNTAIN BIKE 2016 #4

1 - 2º MTB PEDAL DE FERRO

1 - COPA LEANDRO GAUDERETO DE MOUNTAIN BIKE

8 - 4º DESAFIO SERRA DA GANDARELA DE MOUNTAIN BIKE

13 a 15 - CIMTB - COPA INTERNACIONAL DE MTB

21 - APUANA TRAIL BIKE

22 - 14º INTERCITY DE MOUNTAIN BIKE 2016

22 - MARATHON CUP MTB #2

29 - DESAFIO MOUNTAIN BIKE #2

29 - 4° COPA MINAS DE MOUNTAIN BIKE 2016 #3

29 - 5º MOUNTAIN BIKE DE PIRAÚBA

29 - COPA GRANDE SERTÃO #2

JUNHO 2016

5 - 2° CORRIDA DE MOUNTAIN BIKE DA JUVENTUDE

11 - COPA MAXXIS DE XCO BY RAVELLI - XCO

12 - COPA MAXXIS DE XCO BY RAVELLI - XCM

12 - COPA 2016 MOUNTAIN BIKE #1

12 - 4° COPA MINAS DE MOUNTAIN BIKE 2016 #5

19 - 1° TRILHAO BRTRILHAS MTB

19 - CAMPEONATO MINEIRO DE MARATONA 2016 #FINAL

26 - CAMPEONATO MINEIRO DE XCO #1

26 - DESAFIO 6 HORAS DE MARIANA

JULHO 2016

3 - CAMPEONATO MINEIRO DE XCO 2016 # FINAL

10 - COPA PEDAL MINEIRO DE MOUNTAIN BIKE # 3

10 - DESAFIO ANTONIO FRANCISCO LISBOA

10 - COPA GIRUS DE MTB - 2016

10 - GP SENSE DUAS RODAS MTB

16 e 17 - CAMPEONATO BRASILEIRO DE MTB XCO

23 e 24 - ULTRAMARATONA SERTÃO DIAMANTE 2016

24 - 4° COPA MINAS DE MOUNTAIN BIKE 2016

31 - 6° MOUNTAIN BIKE SICOOB

31 - DESAFIO BROU BRUTO DE MOUNTAIN BIKE

AGOSTO 2016

7 - II DESAFIO DA ROCHA DE MTB

7 - CIRCUITO ESTRADA REAL DE MTB

14 - 1º XCP 14 BIS

27 e 28 - IBITIPOCA TRIP TRAIL – MTB ADVENTURE RACE 2016

28 - COPA 2016 MOUNTAIN BIKE #2

SETEMBRO 2016

02 03 e 04 - JOGOS DE MINAS 2016

4 - COPA BIG MAIS MOUNTAIN BIKE # 2

4 - COPA PEDAL MINEIRO DE MOUNTAIN BIKE # 4

10 - DESAFIO MOVE IT XCO NOTURNO

11 - DESAFIO DAS GRUTAS XC 2016

11 - MARATONA DA FUMAÇA

16,17 e 18 - IRON BIKER BRASIL 2016

25 - XTERRA 2016

OUTUBRO 2016

9 - 4° COPA MINAS DE MOUNTAIN BIKE 2016

9 - DUST - ROCHEDO DE MINAS XCO

16 - COPA 2016 MOUNTAIN BIKE #3

23 - DESAFIO FOR RIDE DE MOUNTAIN BIKE #2

23 - MARATHON CUP MTB #3

23 - 1° MOUNTAIN BIKE DAS GERAIS ITACOLOMI

30 - GP RADICAL BIKE MOUNTAIN BIKE

30 - 4° COPA MINAS DE MOUNTAIN BIKE 2016

NOVEMBRO 2016

5 - DESAFIO EXTREMO ESTRADA REAL - ETAPA 100 MILHAS SABARABUÇÚ

13 - XTERRA 2016

19 e 20 - CIMTB - COPA INTERNACIONAL DE MTB

27 - TROFEU REI DOS MONTES DE MTB

DEZEMBRO 2016

4 - TRIP TRAILPRADENSE

4 - COPA 2016 MOUNTAIN BIKE #4

11 - MOUNTAIN BIKE SERRA DO CIPÓ 2016 11° EDIÇÃO

CALENDÁRIO DE PROVAS 2017 - FEDERAÇÃO MINEIRA DE CICLISMO

JANEIRO 2017

29 - XXII INTERCITY ONÇA DO PITANGUI 2017

FEVEREIRO 2017

5 - 5° COPA MINAS DE MOUNTAIN BIKE # SANTO ANTÔNIO DO GRAMA

12 - COPA GRANDE SERTÃO #1

19 - DESAFIO DO ROCAMBOLE DE MTB

MARÇO 2017

03 a 05 - COPA INT. DE MTB

12 - CAMPEONATO MINEIRO VENZO DE MARATONA

18 e 19 - XTERRA CAMP IBITIPOCA

19 - COPA BIG MAIS XCO

19 - GOLDEN BIKER #1

25 - CAMPEONATO MINEIRO DE UP HILL

26 - BIKE RACE BRASIL MTB CUP #1

26 - 2º DESAFIO MOUNTAIN BIKE SANTA HELENA

ABRIL 2017

2 - CAMPEONATO UBERLANDENSE FUTEL DE MTB #1

2 - DESAFIO FOR RIDE DE MTB

2 - COPA BIKE LIGHT XCO

8 e 9 - XTERRA VALE DO AÇO

9 - BIKE ENDURO DE MARIANA

9 - SUL MINEIRO XCO # 1

21 - 8° CROSS COUNTRY BEM-TE-VI

23 – MARATONA INT ESTRADA REAL

23 - 4° DESAFIO ARCOS DE MTB

29 - CIRCUITO DESAFIO EXTREMO ESTRADA REAL # 1

30 - COPA GRANDE SERTÃO #2

30 - 5° COPA MINAS DE MTB # MANHUAÇU

MAIO 2017

6 - CIPÓ BIKE

7 - MARATHON CUP MTB #1

7 - III MTB PEDAL DE FERRO

7 - 1° MARATONA DO MILHO MTB

14 - SUL MINEIRO XCO #2

20 - CAMINHOS DOS CRISTAIS

21 - COPA MINAS DE MTB # SEM PEIXE

21 - COPA MINAS RACE MARATONA ECOLÔGICA MTB

21 - COPA 2017 MOUNTAIN BIKE #1

28 - 15º INTERCITY DE MTB

JUNHO 2017

3 - COPA UCIP DE MOUNTAIN BIKE

4 - COPA UCIP DE MOUNTAIN BIKE

4 - TROFÉU CATAGUASES DE MTB

4 - BTT EXTREME

4 - COPA ATALAIA DE MTB

09 a 11 - CIMTB

18 - DESAFIO MINEIRO DE XCP

18 - CORRIDA DE MOUNTAIN BIKE DA FESTA DE SÃO JOÃO

18 - III DESAFIO DA ROCHA DE MTB

18 - CAMINHOS DOS CRISTAIS

25 - SUL MINEIRO XCO # 3

25 - BIKE RACE BRASIL MTB CUP #2

25 - COPA GRANDE SERTÃO #3

JULHO 2017

2 - CAMPEONATO MINEIRO DE XCO

2 - XCO INTERNACIONAL ESTRADA REAL

2 - MARATHON CUP MTB #2

2 - DESAFIO ENTRE MONTANHAS

2 - 1º DESAFIO MTB PARAOBEPA

5 a 9 - CIPO CUP MTB BIKE CHALLENGE

9 - REI DOS MONTES DE MTB

9 - 1° MOUNTAIN BIKE XCP DE POCRANE

9 - COPA MOUNTAIN BIKE #2

9 - MTB RACE SERIES

16 - COPA MINAS DE MTB # SEM PEIXE

16 - SUL MINEIRO XCO # 4

16 - 1º GUMA BIKER SERRA DO ROLA MOÇA IBIRITÉ.

22 e 23 - XTERRA CAMP OURO PRETO

22 e 23 - ULTRAMARATONA SERTÃO DIAMANTE

30 - COPA MINAS DE MTB # SANTA BÁRBARA

30 - DESAFIO DA PEDRA GRANDE

AGOSTO 2017

6 - CAMPEONATO UBERLANDENSE FUTEL DE MTB #3

6 - 5° COPA MINAS DE MOUNTAIN BIKE # SANTO ANTÔNIO DO GRAMA

6 - DESAFIO DE MTB

6 - MINAS BIKE RACE MTB

6 - DESAFIO TIRADENTES DE MARATONA DE MOUNTAIN BIKE

13 - MOUNTAIN BIKE SERRA DO CIPÓ - 12ª EDIÇÃO

13 - 1ª MARATONA DE MOUNTAIN BIKE DE FLORESTAL

18 a 20 - CIMTB

26 - 100 MILHAS DO SABARABUÇU

27 - CORRIDA MTB OURO PRETO

27 - CIPÓ / LAPINHA

27 - 3° MTB FORTUNA DE MINAS

SETEMBRO 2017

2 e 3 - COPA BIG MAIS MOUNTAIN BIKE

3 - MARATHON CUP MTB INTERNACIONAL

3 - DESAFIO ROTA DAS GRUTAS

2 e 3 - IBITIPOCA TRIP TRAIL – MTB ADVENTURE RACE 10 COPA MOUNTAIN BIKE #4

10 - COPA INCONFIDENTES #2

16 e 17 - IRON BIKER BRASIL

24 - SUL MINEIRO XCO # 5

24 - 3° CORRIDA DA JUVENTUDE DE MOUNTAIN BIKE

24 - BIKE RACE BRASIL MTB CUP # FINAL

30 - XTERRA ESTRADA REAL 2017

OUTUBRO 2017

1 - XTERRA ESTRADA REAL

1 - 4a MARATONA MOUNTAIN BIKE DE NANUQUE

8 - DESAFIO FOR RIDE DE MOUNTAIN BIKE #2 - Edição Primavera

8 - COPA MINAS DE MOUNTAIN BIKE

4 - 2° DESAFIO ANTONIO FRANCISCO LISBOA DE MTB

15 - DESAFIO CAUÃ MTB DUPLAS

22 - 7° MOUNTAIN BIKE SÃO JOSÉ DA LAPA

22 - VOLTA DA FUMAÇA

29 – TROFÉU MOUNTAIN BIKE MINAS GERAIS

NOVEMBRO 2017

5- TROFÉU TIRADENTES DE MOUNTAIN BIKE

5 - CAMPEONATO UBERLANDENSE FUTEL DE MTB # FINAL

5 - GP RADICAL DE MTB

5 - COPA 2017 MOUNTAIN BIKE # FINAL

11 e 12 - XTERRA CAMP JUIZ DE FORA

ANEXO A – ESCALA PARA DOR ANTERIOR DO JOELHO (EDAJ – AKPS)

MINISTÉRIO DA EDUCAÇÃO

Universidade Federal dos Vales do Jequitinhonha e Mucuri

Comitê de Ética em Pesquisa

ESCALA PARA DOR ANTERIOR DO JOELHO (EDAJ – AKPS)

Em cada questão, circule a letra que melhor descreve os atuais sintomas relacionados ao seu joelho.

1. Você caminha mancando?

a. Não

b. Levemente ou de vez em quando

c. Constantemente

2. O seu joelho suporta o seu peso?

a. Apóio totalmente, sem dor

b. Apóio, mas sinto dor

c. É impossível suportar o peso

3. Ao caminhar

a. Não tenho limites para caminhar

b. Caminho mais que 2 km

c. Caminho entre 1 e 2 km

d. Não consigo

4. Ao subir / descer escadas

a. Não tenho dificuldade

b. Sinto um pouco de dor ao descer

c. Sinto dor ao descer e ao subir

d. Não consigo

5. Ao agachar

a. Não tenho dificuldade

b. Sinto dor após agachamentos repetidos

c. Sinto dor a cada agachamento

d. Somente agacho com diminuição de meu peso (me apoiando)

e. Não consigo

6. Ao correr

a. Não tenho dificuldade

b. Sinto dor após correr mais do que 2 km

c. Sinto dor leve desde o começo

d. Sinto dor intensa

e. Não consigo

7. Ao pular/saltar

a. Não tenho dificuldade

b. Tenho um pouco de dificuldade

c. Sinto dor constante

d. Não consigo

8. Ao sentar com os joelhos flexionados/dobrados por período prolongado

a. Não tenho dificuldade

b. Sinto dor para me manter sentado após ter realizado exercícios

c. Sinto dor constante

d. A dor faz com que necessite estender (esticar) os joelhos de tempos em tempos

e. Não consigo

9. Dor

a. Nenhuma

b. Leve e ocasional

c. A dor atrapalha o sono

d. De vez em quando é intensa

e. Constante e intensa

10. Inchaço (edema)

a. Nenhum

b. Após esforço intenso

c. Após atividades diárias

d. Toda noite

e. Constante

11. Movimentos anormais (subluxação) e doloridos da rótula (patela)

a. Não ocorre

b. Ocorre ocasionalmente durante atividades esportivas

c. Ocorre ocasionalmente durante atividades diárias

d. Já tive pelo menos um deslocamento

e. Já tive mais que dois deslocamentos

12. Atrofia da coxa (tamanho da coxa)

a. Nenhuma alteração do tamanho da coxa

b. Leve alteração do tamanho da coxa

c. Severa alteração do tamanho da coxa

13. Sente dificuldade para flexionar/dobrar o joelho?

a. Nenhuma

b. Leve

c. Muita

ANEXO B – ESCALA VISA-P

MINISTÉRIO DA EDUCAÇÃO

Universidade Federal dos Vales do Jequitinhonha e Mucuri

Comitê de Ética em Pesquisa

ESCALA VISA-P

1. Por quantos minutos você consegue ficar sentado sem dor?

0 minuto 100 minutos

0 1 2 3 4 5 6 7 8 9 10

2. Você sente dor ao descer escadas num ritmo de marcha normal?

dor forte ou severa sem dor

0 1 2 3 4 5 6 7 8 9 10

3. Você sente dor no joelho quando o estende totalmente de forma ativa e com apoio de peso?

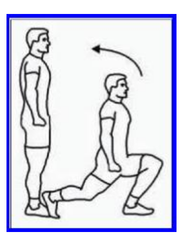
dor forte ou severa sem dor

0 1 2 3 4 5 6 7 8 9 10

4. Você sente dor quando faz o exercício afundo* com apoio de peso total?

dor forte ou severa sem dor

0 1 2 3 4 5 6 7 8 9 10



Exercício afundo

5. Você tem problemas ao agachar?

incapaz sem problemas

0	1	2	3	4	5	6	7	8	9	10

6. Você sente dor durante ou imediatamente após saltitar 10 vezes em uma perna só?

dor forte ou severa/incapaz sem dor

0	1	2	3	4	5	6	7	8	9	10

7. Atualmente, você está praticando algum esporte ou outro tipo de atividade física?

0	Não
4	Treinamento e/ou competição com restrições
7	Treinamento sem restrição, mas não competindo no mesmo nível anterior ao início dos sintomas
10	Competindo no mesmo nível ou nível mais alto do que quando os sintomas começaram

8. Por favor, complete somente uma das questões, A, B ou C, conforme a explicação abaixo.

• Se você não sente dor ao praticar esportes, por favor, responda somente a questão 8A.

• Se você sente dor ao praticar algum esporte, mas esta dor não o impede de praticar a atividade esportiva, por favor, responda somente a questão 8B.

• Se você sente dor que o impede de praticar atividades esportivas, responda somente a questão 8C.

8A. Se você não sente dor ao praticar esporte, por quanto tempo você consegue treinar/praticar?

Não consigo treinar/praticar	0-5 minutos	6-10 minutos	11-15 minutos	Mais de 15 minutos
0	7	14	21	30

OU 8B. Se você sente dor ao praticar esporte, mas a dor não o impede de completar/praticar a atividade esportiva, por quanto tempo você consegue treinar/praticar?

Não consigo treinar/praticar	0-5 minutos	6-10 minutos	11-15 minutos	Mais de 15 minutos
0	4	10	14	20

OU 8C. Se você sente dor que o impede de completar o seu treinamento/prática esportiva, por quanto tempo você consegue treinar/praticar?

Não consigo treinar/praticar	0-5 minutos	6-10 minutos	11-15 minutos	Mais de 15 minutos
0	2	5	7	10

ANEXO C – ESCALA FUNCIONAL ESPECÍFICA

MINISTÉRIO DA EDUCAÇÃO

Universidade Federal dos Vales do Jequitinhonha e Mucuri

Comitê de Ética em Pesquisa

ESCALA FUNCIONAL ESPECÍFICA

Identifique até três (03) atividades importantes para as quais você está incapacitado ou tendo dificuldade para realizar como resultado de sua dor anterior no joelho ou de sua dor lombar. Para cada uma delas, pontue de acordo com a escala abaixo:

0	1	2	3	4	5	6	7	8	9	10

Incapaz de realizar a atividade

Capaz de realizar a atividade no mesmo nível antes do problema atual

ATIVIDADE	PONTUAÇÃO
1.	
2.	
3.	

ANEXO D – APROVAÇÃO COMITÊ DE ÉTICA EM PESQUISA UFVJM

cep comitê de ética em pesquisa

UNIVERSIDADE FEDERAL DOS VALES DO JEQUITINHONHA E MUCURI

Plataforma Brasil

PARECER CONSUBSTANCIADO DO CEP

Considerações sobre os Termos de apresentação obrigatória:

Foram apresentados: Projeto de Pesquisa, Folha de Rosto, Cronograma, Carta da instituição co-partícipe e TCLE.

Coleta de dados prevista para iniciar em 01/09/2017

Recomendações:

- Segundo a Carta Circular nº. 003/2011/CONEP/CNS, de 21/03/11, há obrigatoriedade de rubrica em todas as páginas do TCLE pelo sujeito de pesquisa ou seu responsável e pelo pesquisador, que deverá também apor sua assinatura na última página do referido termo.

- Relatório final deve ser apresentado ao CEP ao término do estudo, em 13/04/2018. Considera-se como antiética a pesquisa descontinuada sem justificativa aceita pelo CEP que a aprovou.

Conclusões ou Pendências e Lista de Inadequações:

Todas as pendências foram atendidas.

O projeto atende aos preceitos éticos para pesquisas envolvendo seres humanos preconizados na

Resolução 466/12 CNS.

Considerações Finais a critério do CEP:

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_819292.pdf	22/08/2017 17:20:46		Aceito
Declaração de Instituição e Infraestrutura	Carta_coparticipante_SCELETUS.pdf	22/08/2017 17:19:29	Guilherme Ribeiro Branco	Aceito
Outros	Questionario_de_lesoes.pdf	27/07/2017 20:26:53	Guilherme Ribeiro Branco	Aceito
Projeto Detalhado / Brochura Investigador	Projeto_de_pesquisa_mestrado_Guilherme_Ribeiro_Branco.pdf	10/07/2017 22:13:27	Guilherme Ribeiro Branco	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE_Identificacao_do_perfil_de_risco_para_DAJ_e_DL_em_ciclistas_de_MTB.pdf	10/07/2017 22:12:51	Guilherme Ribeiro Branco	Aceito
Orçamento	Orcamento.pdf	04/06/2017 08:58:28	Guilherme Ribeiro Branco	Aceito
Cronograma	CRONOGRAMA.pdf	04/06/2017 08:34:03	Guilherme Ribeiro Branco	Aceito
Folha de Rosto	Folha_de_Rosto_Assinada_Projeto_Pesquisa_Guilherme_Ribeiro_Branco.pdf	30/05/2017 14:08:55	Guilherme Ribeiro Branco	Aceito

Situação do Parecer:

Aprovado

Necessita Apreciação da CONEP:

Não

DIAMANTINA, 25 de Agosto de 2017

Assinado por:

Disney Oliver Sivieri Junior

(Coordenador)