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Validade e precisão diagnóstica de quatro testes isométricos com dinamômetro portátil para avaliação da força dos isquiotibiais

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Dedicatória

Dedico este trabalho a todos os fisioterapeutas que atuam de forma clínica e se beneficiarão do nosso estudo.

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RESUMO

Introdução: A avaliação da força muscular, especialmente dos músculos isquiotibiais, é fundamental na reabilitação de lesões e na prevenção de futuras ocorrências. Os dinamômetros isocinéticos são o padrão-ouro para medir a força muscular, mas apresentam limitações de custo e portabilidade, tornando os dinamômetros manuais (HHD) uma alternativa viável. Este estudo investiga a validade e precisão diagnóstica de quatro testes isométricos com HHD em comparação ao dinamômetro isocinético para detectar assimetrias de força nos membros inferiores.

Métodos: O estudo transversal incluiu 30 homens ativos que completaram sessões de teste de força máxima em dois dias separados: uma sessão com dinamômetro isocinético e outra com dinamômetro manual. Os participantes foram avaliados em quatro posições de teste isométrico com o HHD: posição A (prono com joelho a 90º), posição B (prono com joelho a 30º), posição C (supino com joelho a 90º) e posição D (sentado com joelho a 90º). A ordem dos testes foi aleatória. A força, o torque e o índice de simetria de membros (LSI) foram comparados entre os testes usando ANOVA e o coeficiente de correlação de Pearson ou Spearman. A precisão diagnóstica dos testes HHD foi calculada para detectar assimetrias de força maiores que 10% em comparação com os testes isocinéticos.

Resultados: As posições C e D do HHD mostraram melhor correlação com os torques concêntricos e excêntricos do dinamômetro isocinético. No entanto, todas as correlações foram consideradas de fracas a moderadas, e nenhum dos testes HHD apresentou alta precisão para identificar assimetrias superiores a 10% entre os membros. A precisão diagnóstica variou entre 46,7% e 63,3%, indicando limitações na substituição dos testes isocinéticos pelos testes com HHD para avaliação de assimetrias.

Discussão: Este estudo demonstra que, embora as posições C e D do HHD apresentem correlação moderada com os torques isocinéticos, sua precisão diagnóstica é insuficiente para substituir o dinamômetro isocinético na detecção de assimetrias de força entre os membros. A variabilidade na padronização dos protocolos de testes isométricos limita as conclusões sobre a validade do HHD. Outros estudos também encontraram correlações moderadas ao comparar dinamômetros manuais com métodos isocinéticos, destacando que a posição do corpo pode influenciar a precisão dos testes de força isométrica.

Conclusão: Os testes com HHD nas posições C e D mostraram correlações moderadas com o dinamômetro isocinético, mas nenhum apresentou precisão diagnóstica suficiente para avaliar com segurança a assimetria entre os membros. Portanto, recomenda-se o uso do dinamômetro isocinético quando possível, especialmente para avaliar a simetria de força dos isquiotibiais. Em situações em que o dinamômetro isocinético não está disponível, as posições C e D do HHD podem ser opções secundárias, mas com limitações reconhecidas.

Palavras-chave: Força muscular; flexores do joelho; dinamometria; isocinético.

ABSTRACT

Introduction: Muscle strength assessment, especially of the hamstring muscles, is crucial in injury rehabilitation and prevention. Isokinetic dynamometers are the gold standard for measuring muscle strength but are limited by cost and portability, making handheld dynamometers (HHD) a viable alternative. This study investigates the validity and diagnostic accuracy of four isometric HHD tests compared to isokinetic dynamometry for detecting limb strength asymmetries.

Methods: This cross-sectional study included 30 active men who completed maximum strength testing sessions over two separate days: one with an isokinetic dynamometer and another with a handheld dynamometer. Participants were evaluated in four isometric HHD test positions: position A (prone with knee at 90°), position B (prone with knee at 30°), position C (supine with knee at 90°), and position D (sitting with knee at 90°). The test order was randomized. Force, torque, and limb symmetry index (LSI) were compared across tests using ANOVA and Pearson or Spearman correlation coefficients. The diagnostic accuracy of the HHD tests was calculated for detecting limb asymmetries greater than 10% compared to isokinetic tests.

Results: HHD positions C and D showed better correlations with concentric and eccentric peak torques from isokinetic tests. However, all correlations were considered weak to moderate, and none of the HHD tests demonstrated high accuracy for identifying asymmetries above 10% between limbs. Diagnostic accuracy ranged from 46.7% to 63.3%, indicating limitations in replacing isokinetic tests with HHD tests for asymmetry assessment.

Discussion: This study shows that while HHD positions C and D demonstrate moderate correlation with isokinetic torques, their diagnostic accuracy is insufficient to replace isokinetic dynamometry in detecting limb strength asymmetries. The variability in standardizing isometric test protocols limits conclusions on HHD validity. Other studies have also found moderate correlations when comparing handheld and isokinetic dynamometers, emphasizing that body position may influence the accuracy of isometric strength tests.

Conclusion: HHD tests in positions C and D showed moderate correlations with isokinetic dynamometry, but none demonstrated sufficient diagnostic accuracy for safely assessing limb asymmetry. Therefore, the use of isokinetic dynamometry is recommended, when possible, especially for hamstring symmetry assessment. When isokinetic dynamometry is unavailable, HHD positions C and D may serve as secondary options, though with recognized limitations.

Keywords: Data Accuracy; Muscle Strength Dynamometer; Hamstring Muscles; Correlation Measures.

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LISTA DE ABREVIATURAS E SIGLAS

HHD	Hand-Held Dynamometer
IK	Isokinetic Dynamometer
LSI	Limb Symmetry Index
N	Newton
Nm	Newton-Meters
Nm/kg	Newton-Meters per Kilogram
CI	Confidence Interval
ICC	Intraclass Correlation Coefficient
PPV	Positive Predictive Value
NPV	Negative Predictive Value
AUC	Area Under the Curve
ACLR	Anterior Cruciate Ligament Reconstruction
1 RM	One-Repetition Maximum
SD	Standard Deviation
UFCSPA	Federal University of Health Sciences of Porto Alegre
TP	True Positive
TN	True Negative
FP	False Positive
FN	False Negative
ANOVA	Analysis of Variance

SUMÁRIO

1 CONTEXTUALIZAÇÃO

As lesões musculares dos isquiotibiais (HSI) são lesões que ocorrem comumente durante sprints, acelerações e desacelerações, sendo as lesões mais prevalentes em esportes como futebol, futebol australiano e rugby (Jokela et al., 2023; Opar et al., 2012; Vidoni et al., 2018). Apesar dos esforços de clínicos e pesquisadores para encontrar estratégias que reduzam a incidência desse tipo de lesão, ainda não houve uma redução significativa, com as taxas de incidência aumentando ao longo das temporadas (Ekstrand et al., 2023). Ekstrand et al. analisaram todas as lesões ocorridas no futebol europeu ao longo de 21 anos; as lesões nos isquiotibiais aumentaram de 12% na temporada de 2001/2002 para 24% na temporada de 2021/2022, constituindo 19% de todas as lesões registradas durante esse período (Ekstrand et al., 2023), afetando diretamente o desempenho da equipe, as finanças dos clubes e a saúde dos atletas (Eliakim et al., 2020). Por isso, é essencial conter a ocorrência dessa lesão.

A HSI resulta da interação de uma série de fatores de risco intrínsecos e extrínsecos, conhecidos como rede de determinantes (Bittencourt et al., 2016). Entre eles, a força muscular da musculatura posterior da coxa representa uma influência significativa na manifestação das lesões dos isquiotibiais (Timmins et al., 2016). Estudos prospectivos indicam que a baixa força excêntrica dos isquiotibiais é um importante fator de risco para a ocorrência dessa lesão (Edouard et al., 2024; Fanchini et al., 2020; Lee et al., 2018; Timmins et al., 2016). O aumento da força excêntrica dos músculos flexores do joelho tem sido um dos objetivos nos protocolos de reabilitação para lesões nos isquiotibiais (Mendiguchia & Brughelli, 2011; Valle et al., 2015; Whiteley et al., 2018), sendo a recuperação da força um indicador crucial na progressão do tratamento e no retorno à atividade esportiva (Erickson & Sherry, 2017). Portanto, é essencial utilizar métodos validados para avaliar a força muscular dos flexores do joelho, tanto para fins preventivos quanto para a reabilitação dessa lesão.

A principal função do músculo é exercer força, que é definida como a capacidade de alterar o estado de repouso ou movimento da matéria (Winter & Fowler, 2009). A força muscular está diretamente relacionada ao desempenho físico, desde a saúde de idosos (Cadore, 2014) até o alto rendimento (McGuigan et al., 2012). Intervenções para fortalecimento muscular são essenciais para melhorar a saúde de diferentes faixas etárias e prevenir lesões esportivas (Faigenbaum et al., 2009). Ou seja, a força muscular desempenha um papel na promoção da saúde, na melhoria do desempenho esportivo, na facilitação da reabilitação e na prevenção de lesões musculoesqueléticas.

Sabendo disso, clínicos e pesquisadores têm utilizado uma variedade de dispositivos e parâmetros para avaliar a força muscular dos flexores do joelho. Embora o dinamômetro isocinético seja considerado o padrão-ouro para avaliações de força muscular (Baroni et al., 2020), sua aplicação é frequentemente limitada devido ao alto custo, à falta de portabilidade e à necessidade de protocolos demorados, tornando-o impraticável para a maioria das equipes esportivas e para a utilização em contextos de reabilitação. Assim, outros métodos mais acessíveis e igualmente validados tornaram essa avaliação viável e aplicável, como é o caso da dinamometria manual (HHD) (Edwards & Mcdonnell, 1974; Stark et al., 2011) – um dispositivo capaz de avaliar a força gerada durante uma contração muscular estática, sem alterar o comprimento do músculo (Reurink et al., 2016).

Para a avaliação da força muscular isométrica, a escolha das posições articulares nas quais a força é exercida é uma variável-chave, pois essas posições podem influenciar diretamente os resultados obtidos (Ogborn et al., 2023). Em geral, posições padronizadas são comumente adotadas para dinamometria isométrica dos isquiotibiais, incluindo ângulos articulares específicos do membro inferior. Embora diversos testes de força dos isquiotibiais com HHD pareçam oferecer reprodutibilidade aceitável, a correlação dos resultados obtidos através dos testes isométricos em comparação com a dinamometria isocinética (Baron et al., 2024; Lipovšek et al., 2022; Whiteley et al., 2012) permanece incerta.

Do ponto de vista prático, é fundamental avaliar a correlação entre os valores obtidos por meio de testes com dinamômetro portátil (HHD) e aqueles fornecidos pela dinamometria isocinética, bem como investigar a precisão diagnóstica desses testes na identificação de indivíduos com assimetria de força entre os membros. Assim, identificar quais posições de teste com HHD melhor se assemelham com os resultados da dinamometria isocinética pode auxiliar os fisioterapeutas na assertividade da escolha da opção mais apropriada para adotar em seu ambiente clínico. Embora existam estudos que validem o uso de variadas posições articulares para a avaliação da força isométrica dos isquiotibiais (Larson et al., 2022; Reurink et al., 2016; Robaina et al., 2023), ainda não é claro qual protocolo mais se assemelha ao desempenho no teste de força isocinética.

REFERÊNCIAS DA CONTEXTUALIZAÇÃO

Baron, M., Divernois, G., Grandjean, B., & Guex, K. (2024). Validity and Reliability of Handheld Dynamometry to Assess Isometric Hamstrings and Quadriceps Strength at Varying Muscle Lengths. *Journal of Sport Rehabilitation*, *33*(4), 267–274. https://doi.org/10.1123/jsr.2023-0256

Baroni, B. M., Ruas, C. V., Ribeiro-Alvares, J. B., & Pinto, R. S. (2020). Hamstring-to-Quadriceps Torque Ratios of Professional Male Soccer Players: A Systematic Review. *Journal of Strength and Conditioning Research*, *34*(1), 281–293. https://doi.org/10.1519/JSC.0000000000002609

Bittencourt, N. F. N., Meeuwisse, W. H., Mendonça, L. D., Nettel-Aguirre, A., Ocarino, J. M., & Fonseca, S. T. (2016). Complex systems approach for sports injuries: moving from risk factor identification to injury pattern recognition—narrative review and new concept. *British Journal of Sports Medicine*, *50*(21), 1309–1314. https://doi.org/10.1136/bjsports-2015-095850

Cadore, E. (2014). Strength and Endurance Training Prescription in Healthy and Frail Elderly. *Aging and Disease*. https://doi.org/10.14336/ad.2014.0500183

Edouard, P., Lahti, J., Fleres, L., Ahtiainen, J., Ulvila, J.-J., Lehtinen, T., Virtanen, N., Taipale, T., Bellver, M., Peltonen, V., Thibault, M., Huuhka, T., Toivonen, R.-M., Morin, J.-B., & Mendiguchia, J. (2024). A musculoskeletal multifactorial individualised programme for hamstring muscle injury risk reduction in professional football: results of a prospective cohort study. *BMJ Open Sport & Exercise Medicine*, *10*(1), e001866. https://doi.org/10.1136/bmjsem-2023-001866

Edwards, R. H. T., & Mcdonnell, M. (1974). HAND-HELD DYNAMOMETER FOR EVALUATING VOLUNTARY-MUSCLE FUNCTION. *The Lancet*, *304*(7883), 757–758. https://doi.org/10.1016/S0140-6736(74)90947-7

Ekstrand, J., Bengtsson, H., Waldén, M., Davison, M., Khan, K. M., & Hägglund, M. (2023). Hamstring injury rates have increased during recent seasons and now constitute 24% of all injuries in men's professional football: the UEFA Elite Club Injury Study from 2001/02 to 2021/22. *British Journal of Sports Medicine*, *57*(5), 292–298. https://doi.org/10.1136/bjsports-2021-105407

Eliakim, E., Morgulev, E., Lidor, R., & Meckel, Y. (2020). Estimation of injury costs: financial damage of English Premier League teams' underachievement due to injuries. *BMJ Open Sport & Exercise Medicine*, *6*(1), e000675. https://doi.org/10.1136/bmjsem-2019-000675

Erickson, L. N., & Sherry, M. A. (2017). Rehabilitation and return to sport after hamstring strain injury. *Journal of Sport and Health Science*, *6*(3), 262–270. https://doi.org/10.1016/j.jshs.2017.04.001

Faigenbaum, A. D., Kraemer, W. J., Blimkie, C. J. R., Jeffreys, I., Micheli, L. J., Nitka, M., & Rowland, T. W. (2009). Youth Resistance Training: Updated Position Statement Paper From the National Strength and Conditioning Association. *Journal of Strength and Conditioning Research*, *23*(Supplement 5), S60–S79. https://doi.org/10.1519/JSC.0b013e31819df407

Fanchini, M., Steendahl, I. B., Impellizzeri, F. M., Pruna, R., Dupont, G., Coutts, A. J., Meyer, T., & McCall, A. (2020). Exercise-Based Strategies to Prevent Muscle Injury in Elite Footballers: A Systematic Review and Best Evidence Synthesis. *Sports Medicine*, *50*(9), 1653–1666. https://doi.org/10.1007/s40279-020-01282-z

Jokela, A., Valle, X., Kosola, J., Rodas, G., Til, L., Burova, M., Pleshkov, P., Andersson, H., Pasta, G., Manetti, P., Lupón, G., Pruna, R., García-Romero-Pérez, A., & Lempainen, L. (2023). Mechanisms of Hamstring Injury in Professional Soccer Players: Video Analysis and Magnetic Resonance Imaging Findings. *Clinical Journal of Sport Medicine*, *33*(3), 217–224. https://doi.org/10.1097/JSM.0000000000001109

Larson, D., Lorenz, D., & Melton, B. (2022). Can Clinician-Stabilization with Hand-Held Dynamometry Yield a Reliable Measure of Knee Flexion Torque?

International Journal of Sports Physical Therapy, *17*(6). https://doi.org/10.26603/001c.37907

Lee, J. W. Y., Mok, K.-M., Chan, H. C. K., Yung, P. S. H., & Chan, K.-M. (2018). Eccentric hamstring strength deficit and poor hamstring-to-quadriceps ratio are risk factors for hamstring strain injury in football: A prospective study of 146 professional players. *Journal of Science and Medicine in Sport*, *21*(8), 789–793. https://doi.org/10.1016/j.jsams.2017.11.017

Lipovšek, T., Kacin, A., & Puh, U. (2022). Reliability and validity of hand-held dynamometry for assessing lower limb muscle strength. *Isokinetics and Exercise Science*, *30*(3), 231–240. https://doi.org/10.3233/IES-210168

McGuigan, M. R., Wright, G. A., & Fleck, S. J. (2012). Strength Training for Athletes: Does It Really Help Sports Performance? *International Journal of Sports Physiology and Performance*, *7*(1), 2–5. https://doi.org/10.1123/ijspp.7.1.2

Mendiguchia, J., & Brughelli, M. (2011). A return-to-sport algorithm for acute hamstring injuries. *Physical Therapy in Sport*, *12*(1), 2–14. https://doi.org/10.1016/j.ptsp.2010.07.003

Ogborn, D., McRae, S., Larose, G., Leiter, J., Brown, H., & MacDonald, P. (2023). Knee flexor strength and symmetry vary by device, body position and angle of assessment following ACL reconstruction with hamstring grafts at long-term follow-up. *Knee Surgery, Sports Traumatology, Arthroscopy*, *31*(5), 1658–1664. https://doi.org/10.1007/s00167-021-06712-7

Opar, D. A., Williams, M. D., & Shield, A. J. (2012). Hamstring Strain Injuries. *Sports Medicine*, *42*(3), 209–226. https://doi.org/10.2165/11594800-000000000-00000

Reurink, G., Goudswaard, G. J., Moen, M. H., Tol, J. L., Verhaar, J. A. N., & Weir, A. (2016). Strength Measurements in Acute Hamstring Injuries: Intertester Reliability and Prognostic Value of Handheld Dynamometry. *Journal of Orthopaedic & Sports Physical Therapy*, *46*(8), 689–696. https://doi.org/10.2519/jospt.2016.6363

Robaina, B. de Q., Medeiros, D. M., Roberti, L. de S., Franke, R. de A., & Baroni, B. M. (2023). The Single Leg Bridge Test does not replace handheld dynamometer hamstring tests in a clinical setting. *Physical Therapy in Sport*, *63*, 126–131. https://doi.org/10.1016/j.ptsp.2023.08.001

Stark, T., Walker, B., Phillips, J. K., Fejer, R., & Beck, R. (2011). Hand-held Dynamometry Correlation With the Gold Standard Isokinetic Dynamometry: A Systematic Review. *PM&R*, *3*(5), 472–479. https://doi.org/10.1016/j.pmrj.2010.10.025

Timmins, R. G., Bourne, M. N., Shield, A. J., Williams, M. D., Lorenzen, C., & Opar, D. A. (2016). Short biceps femoris fascicles and eccentric knee flexor weakness increase the risk of hamstring injury in elite football (soccer): a prospective cohort study. *British Journal of Sports Medicine*, *50*(24), 1524–1535. https://doi.org/10.1136/bjsports-2015-095362

Valle, X., L.Tol, J., Hamilton, B., Rodas, G., Malliaras, P., Malliaropoulos, N., Rizo, V., Moreno, M., & Jardi, J. (2015). Hamstring Muscle Injuries, a Rehabilitation Protocol Purpose. *Asian Journal of Sports Medicine*, *6*(4). https://doi.org/10.5812/asjsm.25411

Vidoni, A., Gillett, M., Botchu, R., & James, S. (2018). Lower limb muscle injuries: The good, the bad and the ugly. *European Journal of Radiology*, *104*, 101–107. https://doi.org/10.1016/j.ejrad.2018.05.008

Whiteley, R., Jacobsen, P., Prior, S., Skazalski, C., Otten, R., & Johnson, A. (2012). Correlation of isokinetic and novel hand-held dynamometry measures of knee flexion and extension strength testing. *Journal of Science and Medicine in Sport*, *15*(5), 444–450. https://doi.org/10.1016/j.jsams.2012.01.003

Whiteley, R., van Dyk, N., Wangensteen, A., & Hansen, C. (2018). Clinical implications from daily physiotherapy examination of 131 acute hamstring injuries and their association with running speed and rehabilitation progression. *British Journal of Sports Medicine*, *52*(5), 303–310. https://doi.org/10.1136/bjsports-2017-097616

Winter, E. M., & Fowler, N. (2009). Exercise defined and quantified according to the Système International d'Unités. *Journal of Sports Sciences*, *27*(5), 447–460. https://doi.org/10.1080/02640410802658461

2 OBJETIVOS

O objetivo do estudo foi verificar a validade e a acurácia diagnóstica de quatro testes isométricos de isquiotibiais com um dinamômetro portátil isométrico em comparação com a dinamometria isocinética.

3 ARTIGO

VALIDITY AND DIAGNOSTIC ACCURACY OF FOUR HAND-HELD DYNAMOMETER ISOMETRIC TESTS FOR ASSESSING HAMSTRING STRENGTH

(Formatado conforme normas do periódico Physical Therapy in Sport – *Qualis A3, Fator de Impacto 2.2*)

VALIDITY AND DIAGNOSTIC ACCURACY OF FOUR HAND-HELD DYNAMOMETER ISOMETRIC TESTS FOR ASSESSING HAMSTRING STRENGTH

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ABSTRACT

Objective: To evaluate the validity and diagnostic accuracy of four hand-held dynamometer (HHD) isometric tests with the isokinetic dynamometry for assessing hamstring strength.

Design: Cross-sectional study.

Setting: Research laboratory.

Participants: Thirty physically active men.

Main Outcome Measures: Comparison of force and torque values, as well as limb symmetry index (LSI), measured using isokinetic dynamometry and HHD isometric tests performed in four positions: test A (prone, knee at 90°), test B (prone, knee at 30°), test C (supine, knee at 90°), and test D (sitting, knee at 90°). Diagnostic accuracy of HHD tests to detect individuals with between-limb strength asymmetries greater than 10% (i.e., LSI values <90 or >110) was calculated.

Results: HHD test C showed moderate to good correlation with concentric peak torque (r=0.60), while test D showed moderate to good correlation with concentric (r=0.51) and eccentric (r=0.61) peak torques. None of the HHD tests demonstrated sufficient accuracy for identifying individuals with between-limb strength asymmetries greater than 10%, with diagnostic accuracy values ranging between 47% and 63%.

Conclusions: While HHD tests in positions C and D showed moderate to good validity with the isokinetic dynamometry, no HHD test provided sufficient diagnostic accuracy for screening individuals with between-limb strength asymmetry greater than 10%.

Keywords: Muscle strength; Knee flexors; Dynamometry; Isokinetic.

INTRODUCTION

The primary function of muscle is to exert force, which is defined as a factor that tends to change the state of rest or motion of matter and should be measured in Newtons (N) (Winter & Fowler, 2009). The term 'strength' is commonly used in the scientific literature to describe the amount of force a muscle group can produce, particularly its maximal capacity. Strength is closely linked to human physical performance, influencing a range of outcomes from the disability status of older adults (Cadore et al., 2014) to the athletic success of elite competitors (McGuigan et al., 2012). As a result, muscle-strengthening interventions are critical in programs aimed at improving the overall health of young people (Faigenbaum et al., 2009), adults (ACSM, 2009), and elderly (Fragala et al., 2019), as well as individuals with a range of health conditions (Hayes et al., 2019; Morris et al., 2021; Sharman et al., 2019). In the context of musculoskeletal injury rehabilitation, enhancing muscle strength is a typical goal in both conservative treatment programs (Hall et al., 2018; Malliaras et al., 2015; Mendiguchia & Brughelli, 2011; Nascimento et al., 2018) and following orthopedic surgeries (Friedmann-Bette et al., 2018; Jette et al., 2020; Vidmar et al., 2019). Additionally, muscle-strengthening interventions have been proven effective in preventing acute and overuse sports injuries (Lauersen et al., 2018). In summary, muscular strength seems to play a role in promoting health, enhancing sports performance, facilitating rehabilitation, and preventing musculoskeletal injuries.

Assessing muscle strength is a fundamental aspect of routine practice for orthopedic and sports physical therapists. Hamstring strength testing, in particular, has gained considerable attention in the areas of injury prevention and rehabilitation. Current evidence strongly recommends strength testing for individuals who have sustained a hamstring strain injury (HSI) (Hickey et al., 2022; Martin et al., 2022). These tests help predict recovery timelines, facilitate the monitoring of patient progress throughout rehabilitation, and serve as a key criterion for returning to sport following (D. M. Medeiros et al., 2020; MENDIGUCHIA et al., 2017; Whiteley et al., 2018). Healthcare professionals view muscle strength deficits as potential risk factors for HSIs (Ekstrand, Hallén, et al., 2023; Ekstrand, Ueblacker, et al., 2023), a perspective supported by a few cohort studies (Bourne et al., 2015; Burigo et al., 2020; Croisier et al., 2008; Fousekis et al., 2011; Lee et al., 2018; Opar et al., 2015; Timmins et al., 2016). Additionally, weekly monitoring of hamstring strength has proven to be an effective secondary prevention strategy against HSIs (Wollin et al., 2020), further reinforcing the link between hamstring strength and injury. Beyond HSI applications, hamstring strength testing is also recommended as a crucial component in return-to-sport decision-making following knee injuries, particularly in patients who have undergone anterior cruciate ligament (ACL) reconstruction (Kyritsis et al., 2016). Thus, assessing hamstring strength is a key component of daily practice for many physical therapists.

A variety of devices to assess hamstring muscle strength have been used in research and clinical environments. The isokinetic dynamometer, regarded as the gold standard for evaluating muscle strength production capacity in humans through torque measurements (in Newton-meters, Nm) (Brown, 2000), is an electromechanical device known for its high test-retest reproducibility, with intraclass correlation coefficients (ICC) of 0.86–0.96 and 0.85–0.92 for concentric and eccentric assessments of hamstring peak torque, respectively (Almosnino et al., 2012). However, its high cost, lack of portability, and time-consuming protocols render isokinetic dynamometer assessments impractical for most sports teams and rehabilitation centers. In contrast, handheld dynamometers (HHDs) offer a more feasible alternative for physical therapists due to their relatively low cost, portability, and quick protocols (Edwards & Mcdonnell, 1974). Unlike isokinetic dynamometer assessments, which are always conducted with the subject seated, hamstring isometric tests using HHDs can be performed in various positions. Some of the most used positions include sitting with the knee and hip at 90º (ICC of 0.77-0.94) (Larson et al., 2022), lying prone with neutral hip neutral and knee at 30º (ICC of 0.91-0.93) and 90º (ICC of 0.71-0.76) (Goossens et al., 2015; Reurink et al., 2016), and supine with the hip and knee at 90º (ICC of 0.88-0.92) (Whiteley et al., 2018).

While various HHD hamstring strength tests seem to offer acceptable reproducibility, the validity of these isometric tests compared to the gold standard of isokinetic dynamometry remains uncertain. From a practical standpoint, it is essential to determine whether values provided by HHD tests correlate with those of isokinetic dynamometry and if these tests have diagnostic accuracy for screening individuals with between-limb strength asymmetry exceeding acceptable levels. Identifying which HHD test positions best align with isokinetic dynamometry results can assist physical therapists in selecting the most appropriate option to adopt in their clinical setting. Therefore, this study aimed to evaluate the validity and diagnostic accuracy of four HHD isometric tests with the isokinetic dynamometry for assessing hamstring strength.

METHODS

In this cross-sectional study, the volunteers agreed to undergo two maximum strength testing sessions, one with an isokinetic dynamometer and the other with an isometric dynamometer, conducted at the Federal University of Health Sciences of Porto Alegre (UFCSPA) between the years 2023 and 2024. This study was approved by the institutional ethics committee XXXXX, and all volunteers provided informed consent before participating in the study.

Participants

Volunteers were recruited through advertisements on social media linked to the university community. To be included in this study, volunteers had to be male, between the ages of 18 and 35, and regularly engage in physical exercise (e.g., individual sports, team sports, resistance training, etc.). Participants declared that they were free from any current injuries and were fit to undergo the tests. Athletes were excluded from the study if they: 1) had a knee ligament injury within the past year; 2) had hamstring muscle injuries within the past 6 months.

Procedures

The isokinetic dynamometry and HHD tests were conducted on two separate days. The researcher performing the isokinetic dynamometry was blinded to the participants' performance in the HHD tests, and the researcher conducting the HHD tests was likewise blinded to the isokinetic dynamometry results. The order of sessions was counterbalanced, with half of the participants beginning with the isokinetic dynamometry session and the other half starting with the HHD testing session. On the first day, all participants underwent a brief medical history review and eligibility assessment before proceeding to a general warm-up consisting of 10 minutes on a stationary bike. On the second day, participants began directly with the general warm-up.

Isokinetic dynamometry

A standardized isokinetic testing protocol was conducted for assessing concentric and eccentric knee flexor peak torques on the Biodex System 4 Pro isokinetic dynamometer (Biodex Medical Systems, USA) (T. M. Medeiros et al., 2020). After the general warm-up, participants were positioned seated on the isokinetic dynamometer according to the manufacturer’s recommendations. Participants performed 10 concentric knee flexion/extension repetitions at 90°/s with a submaximal effort level for specific warm-up and familiarization with the equipment. Thereafter, two attempts of three consecutive maximum contractions were executed in the concentric–concentric mode (60°/s; 0°–90° of knee flexion) and two attempts of three consecutive maximal contractions in the eccentric–eccentric mode (60°/s; 30°–90° of knee flexion). Attempts were separated by one-minute resting periods. The highest concentric and eccentric torque value were considered the maximum strength for each type of contraction and used for statistical analyses.

Hand-held dynamometry

All assessments were conducted using a calibrated HHD (SP Tech, Medeor Medtech, Florianópolis, SC, Brazil). Participants were assessed in four distinct joint positions, labeled as tests A, B, C, and D. In *'Test A'* (**Figure 1**) (Reurink et al., 2016), the participants were assessed in the prone position, with the hip in a neutral position and the knee flexed to approximately 90° (0° = full knee extension). A belt was positioned over the glutes to secure and prevent compensation, and the HHD was placed just above the malleoli. The participants were asked to perform knee flexion force while the examiner held the HHD to maintain a fixed position. In *'Test B'* (Goossens et al., 2015) (**Figure 1**), the participants were assessed in the prone position, with the hip in a neutral position and the knee flexed to approximately 30° (0° = full knee extension). The participants were asked to perform knee flexion force while the examiner held the HHD to maintain a fixed position. In *'Test C'* (**Figure 1**) (Whiteley et al., 2018), the participants were assessed in the supine position, with the hip and knee flexed to approximately 90°. A belt was used to ensure that the hip remained fixed during the test. The participants were asked to exert knee flexion force against the HHD positioned between their heel and a 50 cm box. Wedges were used on the box to ensure the specified angle. In *'Test D'* (**Figure 1**) (Larson et al., 2022), the participants were assessed sitting on a box with the hip and knee flexed to 90°. The participants were asked to press the HHD positioned between the heel and the box.

The order of the HHD tests was randomized using the website random.org. In each position, participants performed three maximal isometric contractions, each lasting five seconds, with a 30-sec recovery interval between attempts. Verbal encouragement was provided by the researchers during all repetitions to ensure maximal effort from the participants. The highest force value measured in each position was considered for statistical analyses. Torque values were calculated by multiplying force values by the lever arm length, defined as the distance (in meters) between the knee joint and the point of HHD application for each participant.

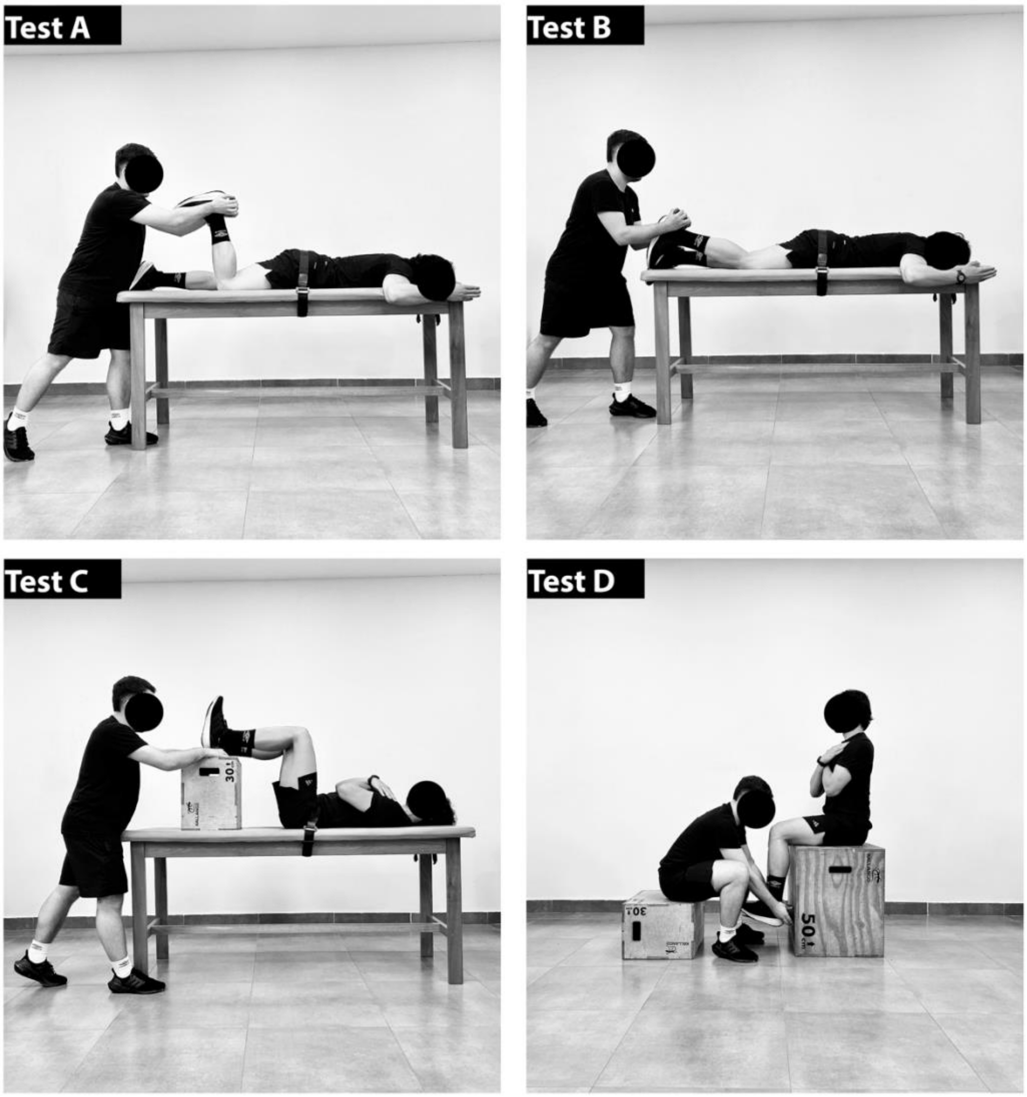

Figure 1: Handheld dynamometer hamstring tests: *'test A'* (top left corner), *'test B'* (top right corner), *test 'C'* (bottom left corner) and *'test D'* (bottom right corner).

Statistical analysis

Descriptive statistics were used to describe the participants' characteristics and outcomes through mean, standard deviation (SD), and 95% confidence interval (CI). Normality of the data was assessed using the Shapiro-Wilk test. Force (measured in Newtons), torque (calculated in Nm and Nm/kg), and limb symmetry index (LSI) provided by the two isokinetic tests and the four HHD isometric tests were compared using a one-way ANOVA, followed by Bonferroni post-hoc. The LSI was calculated using the following formula: 100 - [(non-dominant limb/dominant limb) × 100].

The validity of each HHD isometric test was analyzed using Pearson or Spearman correlation coefficients, depending on whether the data followed a normal or non-normal distribution, respectively, to assess the relationship between its results and those of the isokinetic concentric and eccentric tests. The correlation values were interpreted as follows: <0.5 indicated weak validity, 0.5–0.75 indicated moderate to good validity, and >0.75 indicated excellent validity (Almeida et al., 2017, 2019).

The diagnostic accuracy of the HHD isometric tests compared to isokinetic tests for detecting between-limb strength asymmetries greater than 10% (i.e., LSI values <90 or >110) was evaluated by calculating sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy. Participants were initially classified as positive (i.e., abnormal LSI value) or negative (i.e., normal LSI value) based on the LSI measured during isokinetic tests. Participants were then classified as true positives or true negatives when the isometric test results aligned with the isokinetic test results, and as false positives or false negatives when the isometric test results conflicted with those of the isokinetic test.

Sensitivity measures the proportion of actual positives that are correctly identified (Equation 1). Specificity measures the proportion of actual negatives that are correctly identified (Equation 2). PPV measures the proportion of positive test results that are true positives (Equation 3). NPV measures the proportion of negative test results that are true negatives (Equation 4). Accuracy measures the proportion of all test results that are correctly identified (Equation 5).

Equation 1: $Sensitivity = TP \div (TP + FN)$

Equation 2: $Specificity = TN \div (TN + FP)$

Equation 3: $PPV = TP \div (TP + FP)$

Equation 4: $PPN = TN \div (TN + NF)$

Equation 5: $Accuracy = (TP + TN) \div (\mathrm{TP + TN + FP + FN})$

Where, ‘TP’ is true positive cases, ‘TN’ is true negative cases, ‘FP’ is false positive cases, and ‘FN’ is false negative cases.

RESULTS

Thirty physically active men completed the full study schedule (Table 1). Participants were regularly engaged in strength training, functional training, and/or sports such as football, seven-a-side football, futsal, volleyball, footvolley, tennis, boxing, and running. The weekly frequency of their activity was distributed as follows: two exposures per week (13%), three exposures per week (20%), four exposures per week (20%), five exposures per week (40%), and six exposures per week (7%).

Table 2 presents the force and torque values, as well as the LSI, measured with the two isokinetic tests and the four HHD isometric tests. Significant differences ($p<0.05$) between the tests were found for force and torque values, but not for the LSI.

Correlation between the measures from the IK tests and the HHD isometric tests are detailed in Table 3. The peak torque measured by the concentric isokinetic test showed a weak correlation with isometric tests A and B, while it demonstrated a moderate to good correlation with test C (values in N and Nm) and test D (values in Nm). The peak torque measured by the eccentric isokinetic test showed a weak correlation with isometric tests A, B, and C, while it demonstrated a moderate to good correlation with test D (values in N and Nm). The LSI values measured isokinetic ally showed weak correlations with those obtained from the isometric tests using HHD.

Diagnostic accuracy for HHD isometric tests ranged between 46.7% and 60% for screening subjects with abnormal concentric LSI (Table 4), and between 46.7% and 63.3% for those with abnormal eccentric LSI (Table 5).

	Mean (SD)	95% CI
Age (years)	27 (5)	25 to 29
Weight (kg)	80 (10)	76 to 83
Height (cm)	177 (5)	175 to 179
Body mass index (kg/m^2)	25 (3)	24 to 26

Table 1. Characteristics of the participants.

	Newtons (N)		Newton-meters (Nm)		Newton-meters per kilogram (Nm/kg)		Limb symmetry index (LSI)	
	Mean (SD)	**95% CI**	**Mean (SD)**	**95% CI**	**Mean (SD)**	**95% CI**	**Mean (SD)**	**95% CI**
IK concentric test	-	-	132 (28) [&ad]	125 to 139	1.67 (0.32) [&ad]	1.58 to 1.75	94 (9)	90 to 97
IK eccentric test	-	-	226 (77) [#abcd]	206 to 246	2.84 (0.90) [#abcd]	2.61 to 3.07	95 (10)	91 to 99
HHD test A	172 (34) [bcd]	163 to 180	76 (16) [#&bc]	72 to 80	0.97 (0.23) [#&bc]	0.91 to 1.03	101 (29)	90 to 112
HHD test B	276 (51) [ad]	263 to 289	122 (22) [&ad]	117 to 128	1.55 (0.31) [&ad]	1.47 to 1.63	98 (13)	93 to 103
HHD test C	298 (55) [ad]	284 to 312	132 (26) [&ad]	126 to 139	1.67 (0.31) [&ad]	1.59 to 1.75	102 (18)	95 to 109
HHD test D	213 (43) [abc]	202 to 224	95 (20) [#&bc]	89 to 100	1.20 (0.24) [#&bc]	1.13 to 1.26	96 (15)	90 to 101

[#] Different than IK concentric test; [&] Different than IK eccentric test; [a] Different than HHD test A; [b] Different than HHD test B; [c] Different than HHD test C; [d] Different than HHD test D.

Table 2. Measures from the isokinetic (IK) tests and the hand-held dynamometer (HHD) isometric test.

	IK concentric test		IK eccentric test	
	r or rho	**p-value**	**r or rho**	**p-value**
HHD test A				
N	0.184	0.159	0.034	0.794
Nm	0.208	0.110	-0.011	0.937
Nm/kg	0.326	**0.011**	0.004	0.977
LSI	0.192	0.309	-0.224	0.233
HHD test B				
N	0.334	**0.009**	0.153	0.242
Nm	0.386	**0.002**	0.187	0.152
Nm/kg	0.377	**0.003**	0.008	0.954
LSI	0.412	**0.024**	-0.071	0.711
HHD test C				
N	0.598 *	**<0.001**	0.347	**0.007**
Nm	0.529 *	**<0.001**	0.349	**0.006**
Nm/kg	0.431	**<0.001**	0.177	0.177
LSI	0.119	0.531	0.033	0.863
HHD test D				
N	0.497	**<0.001**	0.606 *	**<0.001**
Nm	0.508 *	**<0.001**	0.559 *	**<0.001**
Nm/kg	0.411	**0.001**	0.439	**<0.001**
LSI	0.212	0.262	-0.082	0.666

*N, Newtons; Nm, Newton-meters; Nm/kg, Newton-meters per kilogram; LSI, limb symmetry index. Significant correlations in bold; * Weak to moderate correlation (> 0.05).*

Table 3. Correlation between the measures from the isokinetic (IK) tests and the hand-held dynamometer (HHD) isometric test.

	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
HHD test A	36.4	52.6	30.8	58.8	46.7
HHD test B	54.5	52.6	40.0	66.7	53.3
HHD test C	63.6	57.9	46.7	73.3	60.0
HHD test D	54.5	57.9	57.9	68.8	56.7

NPV, negative predictive value; PPV, positive predictive value.

Table 4. Diagnostic accuracy of the is hand-held dynamometer (HHD) isometric tests in relation to the isokinetic (IK) concentric test.

	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
HHD test A	40.0	55.0	30.8	64.7	50.0
HHD test B	70.0	60.0	46.7	80.0	63.3
HHD test C	60.0	55.0	40.0	73.3	56.7
HHD test D	40.0	50.0	28.6	62.5	46.7

NPV, negative predictive value; PPV, positive predictive value.

Table 5. Diagnostic accuracy of the is hand-held dynamometer (HHD) isometric tests in relation to the isokinetic (IK) eccentric test.

DISCUSSION

This study was the first to compare four hamstring HHD tests with the gold standard measure of isokinetic dynamometry. The main findings revealed that tests C and D showed the highest correlation values with concentric and eccentric peak torques, respectively. However, both tests demonstrated only moderate to good validity with isokinetic dynamometry. Additionally, none of the HHD tests demonstrated sufficient accuracy to identify individuals with limb asymmetry greater than 10% as measured by isokinetic dynamometry.

All test positions investigated in the present study already have studies validating their use, with test-retest ICC values ranging from 0.71 to 0.92 (Goossens et al., 2015; Larson et al., 2022; Reurink et al., 2016; Whiteley et al., 2018). However, when it comes to validating isometric tests with the isokinetic dynamometry, the current literature still lacks robust evidence to support such conclusions. A systematic review (Stark et al., 2011), published in 2011 and including 19 studies, found that HHD demonstrates moderate to good validity compared to isokinetic tests for most muscle groups. However, the authors noted a lack of standardized protocols, with methodological variability posing challenges, especially for knee joint assessments. Corroborating the systematic review, Baron et al. (2024) aimed to determine the validity and reliability of the HHD for assessing the strength of the hamstring muscles at different muscle lengths, by altering the hip and knee angles during measurement. Isometric assessments of the posterior thigh musculature were performed at 0° of hip flexion and 30° of knee flexion, 0° of hip flexion and 60° of knee flexion, 0° of hip flexion and 90° of knee flexion, 80° of hip flexion and 30° of knee flexion, 80° of hip flexion and 60° of knee flexion, and 80° of hip flexion and 90° of knee flexion. The reliability of the HHD ranged from good to excellent across all positions, except for the seated position with the knee flexed at 30° (ICC = 0.72; 95% confidence interval, 0.42–0.87, $P < 0.001$)(Baron et al., 2024).

Tests C and D showed the greater correlation with concentric and eccentric isokinetic peak torques, respectively. These results are hypothetically attributed to the similarity in angular positions of the knee and hip in relation to the isokinetic dynamometry (i.e., 90° of hip flexion). This rationale is supported by the findings of Whiteley et al. (2012), who evaluated hamstring strength using isokinetic dynamometry and HHD, aiming to standardize strength assessment methodologies. To achieve this, in addition to the isokinetic test, two distinct tests were performed: an isometric test conducted with the subject seated and the knee flexed at 30°, and an eccentric hamstring contraction test performed within a reduced range of 45° to 15° of knee flexion in the prone position. Specifically, regarding the isometric assessment, a high correlation was found (ICC = 0.91; 95% CI 0.78–0.96) between this method and the gold standard, indicating a similarity between them (Whiteley et al., 2012). According to Ogborn et al. (2021), given the biarticular structure of the semitendinosus, long head of the biceps femoris, semimembranosus, and gastrocnemius, the positions of the hip, knee, and ankle must be considered when determining isometric knee flexion strength (Ogborn et al., 2023). According to the study, knee flexion torque was greater in the seated position with the ankle dorsiflexed, suggesting a torque increase that is directly proportional to the increase in hip flexion angle up to the seated position. This is attributed to the optimal positioning in the length-tension relationship of the hamstrings (Worrell et al., 1989).

The reliability of a strength test performed in a clinical setting in diagnosing between-limb strength asymmetry is critical for injury prevention and rehabilitation. Therefore, this study analyzed the diagnostic accuracy of the four HHD tests in identifying participants with asymmetry exceeding 10%. Generally, a test with an area under the curve (AUC) greater than 0.9 indicates high accuracy, while an AUC of 0.7 to 0.9 indicates moderate accuracy, 0.5 to 0.7 indicates low accuracy, and 0.5 represents a random result (Swets, 1988). To our knowledge, this is the first study to evaluate the diagnostic accuracy of HHD tests for the hamstrings. Our findings indicate that all four tests lack sufficient accuracy to be recommended for use by physical therapists. They do not align with those of previous studies that examined the accuracy of HHD tests for the quadriceps. Sinacore et al. (2017) observed that HHD is a fair alternative for screening individuals with LSI of 80% or 90% in isometric electromechanical dynamometry in healthy subjects, although symmetry is typically overestimated (Sinacore et al., 2017). Similarly, in subjects who have undergone ACL reconstruction, Almeida et al. (2019) found that a HHD test had 100% specificity and 63.4% sensitivity to identify those with LSI >10% in isokinetic dynamometry (Almeida et al., 2019).

Although the HHD is an easily accessible instrument, simple to handle, and with well-defined protocols (Reurink et al., 2016), our results show that it is not capable of replacing the strength assessments of the isokinetic dynamometer when the clinician's objective is to assess the asymmetry between the limbs for the hamstring muscles, even though for other muscle groups the diagnostic accuracy has already been evaluated and shown to be effective. It is important to highlight that both the tests we used (Goossens et al., 2015; Larson et al., 2022; Reurink et al., 2016; Whiteley et al., 2018) and some others available in the literature (Kristiansen et al., 2024; Whyte et al., 2024) have been validated and are widely used, and our findings do not aim to discourage the use of portable dynamometers. Our key message is that clinicians should prioritize using an isokinetic dynamometer when available, particularly for analyzing limb asymmetries. For example, if the clinician wishes to assess the level of symmetry between a patient's limbs, no isometric strength test position offers good diagnostic accuracy. However, if an isokinetic dynamometer is not available, we recommend using positions C and D, as they show better correlation than the other tests.

We recognize that our study has some limitations. The HHD evaluation depends on the evaluator's ability to position the device correctly. In our study, especially for tests A and B, the evaluator also needs to be strong enough to resist the force exerted by the subject. Secondly, although the rest interval between tests and repetitions was respected and the isokinetic test was performed on a different day from the HHD evaluation, we cannot rule out the possibility that fatigue may have caused some effect. Additionally, our population consisted of healthy young men who engage in regular sports practice, which cautions us against extrapolating our data to other populations, such as patients in rehabilitation after musculoskeletal injuries or elite athletes. Finally, we chose four isometric tests with the HHD; however, the literature provides other positions and angles that we were unable to include in our study.

CONCLUSION

Hamstring maximum strength obtained in HHD tests C and D achieved moderate to good correlations with concentric and eccentric peak torques measured through the gold standard isokinetic dynamometry. However, none of the HHD tests evaluated in this study demonstrated acceptable diagnostic accuracy for screening individuals with between-limb asymmetry greater than 10%.

Declarations of interest: None

REFERENCES

Almeida, G. P. L., Albano, T. R., & Melo, A. K. P. (2019). Hand-held dynamometer identifies asymmetries in torque of the quadriceps muscle after anterior cruciate ligament reconstruction. *Knee Surgery, Sports Traumatology, Arthroscopy*, *27*(8), 2494–2501. https://doi.org/10.1007/s00167-018-5245-3

Almeida, G. P. L., das Neves Rodrigues, H. L., de Freitas, B. W., & de Paula Lima, P. O. (2017). Reliability and Validity of the Hip Stability Isometric Test (HipSIT): A New Method to Assess Hip Posterolateral Muscle Strength. *Journal of Orthopaedic & Sports Physical Therapy*, *47*(12), 906–913. https://doi.org/10.2519/jospt.2017.7274

Almosnino, S., Stevenson, J. M., Bardana, D. D., Diaconescu, E. D., & Dvir, Z. (2012). Reproducibility of isokinetic knee eccentric and concentric strength indices in asymptomatic young adults. *Physical Therapy in Sport*, *13*(3), 156–162. https://doi.org/10.1016/j.ptsp.2011.09.002

Baron, M., Divernois, G., Grandjean, B., & Guex, K. (2024). Validity and Reliability of Handheld Dynamometry to Assess Isometric Hamstrings and Quadriceps Strength at Varying Muscle Lengths. *Journal of Sport Rehabilitation*, *33*(4), 267–274. https://doi.org/10.1123/jsr.2023-0256

Bourne, M. N., Opar, D. A., Williams, M. D., & Shield, A. J. (2015). Eccentric Knee Flexor Strength and Risk of Hamstring Injuries in Rugby Union. *The American Journal of Sports Medicine*, *43*(11), 2663–2670. https://doi.org/10.1177/0363546515599633

Brown, L. R. (2000). *Isokinetics in Human Performance*. https://api.semanticscholar.org/CorpusID:109685435

Burigo, R. L., Scoz, R. D., Alves, B. M. de O., da Silva, R. A., Melo-Silva, C. A., Vieira, E. R., Hirata, R. P., & Amorim, C. F. (2020). Concentric and eccentric isokinetic hamstring injury risk among 582 professional elite soccer players: a 10-years retrospective cohort study. *BMJ Open Sport & Exercise Medicine*, *6*(1), e000868. https://doi.org/10.1136/bmjsem-2020-000868

Cadore, E. (2014). Strength and Endurance Training Prescription in Healthy and Frail Elderly. *Aging and Disease*. https://doi.org/10.14336/ad.2014.0500183

Croisier, J.-L., Ganteaume, S., Binet, J., Genty, M., & Ferret, J.-M. (2008). Strength Imbalances and Prevention of Hamstring Injury in Professional Soccer Players. *The American Journal of Sports Medicine*, *36*(8), 1469–1475. https://doi.org/10.1177/0363546508316764

Edwards, R. H. T., & Mcdonnell, M. (1974). HAND-HELD DYNAMOMETER FOR EVALUATING VOLUNTARY-MUSCLE FUNCTION. *The Lancet*, *304*(7883), 757–758. https://doi.org/10.1016/S0140-6736(74)90947-7

Ekstrand, J., Hallén, A., Marin, V., & Gauffin, H. (2023). Most modifiable risk factors for hamstring muscle injury in women's elite football are extrinsic and associated with the club, the team, and the coaching staff and not the players themselves: the UEFA Women's Elite Club Injury Study. *Knee Surgery, Sports Traumatology, Arthroscopy*, *31*(7), 2550–2555. https://doi.org/10.1007/s00167-023-07429-5

Ekstrand, J., Ueblacker, P., Van Zoest, W., Verheijen, R., Vanhecke, B., van Wijk, M., & Bengtsson, H. (2023). Risk factors for hamstring muscle injury in male elite football: medical expert experience and conclusions from 15 European Champions League clubs. *BMJ Open Sport & Exercise Medicine*, *9*(1), e001461. https://doi.org/10.1136/bmjsem-2022-001461

Faigenbaum, A. D., Kraemer, W. J., Blimkie, C. J. R., Jeffreys, I., Micheli, L. J., Nitka, M., & Rowland, T. W. (2009). Youth Resistance Training: Updated Position Statement Paper From the National Strength and Conditioning Association. *Journal of Strength and Conditioning Research*, *23*(Supplement 5), S60–S79. https://doi.org/10.1519/JSC.0b013e31819df407

Fousekis, K., Tsepis, E., Poulmedis, P., Athanasopoulos, S., & Vagenas, G. (2011). Intrinsic risk factors of non-contact quadriceps and hamstring strains in soccer: a prospective study of 100 professional players. *British Journal of Sports Medicine*, *45*(9), 709–714. https://doi.org/10.1136/bjsm.2010.077560

Fragala, M. S., Cadore, E. L., Dorgo, S., Izquierdo, M., Kraemer, W. J., Peterson, M. D., & Ryan, E. D. (2019). Resistance Training for Older Adults: Position Statement From the National Strength and Conditioning Association. *Journal of Strength and Conditioning Research*, *33*(8), 2019–2052. https://doi.org/10.1519/JSC.0000000000003230

FRIEDMANN-BETTE, B., PROFIT, F., GWECHENBERGER, T., WEIBERG, N., PARSTORFER, M., WEBER, M.-A., STREICH, N., & BARIÉ, A. (2018). Strength Training Effects on Muscular Regeneration after ACL Reconstruction. *Medicine & Science in Sports & Exercise*, *50*(6), 1152–1161. https://doi.org/10.1249/MSS.0000000000001564

Goossens, L., Witvrouw, E., Vanden Bossche, L., & De Clercq, D. (2015). Lower eccentric hamstring strength and single leg hop for distance predict hamstring injury in PETE students. *European Journal of Sport Science*, *15*(5), 436–442. https://doi.org/10.1080/17461391.2014.955127

Hall, M., Hinman, R. S., Wrigley, T. V., Kasza, J., Lim, B.-W., & Bennell, K. L. (2018). Knee extensor strength gains mediate symptom improvement in knee osteoarthritis: secondary analysis of a randomised controlled trial. *Osteoarthritis and Cartilage*, *26*(4), 495–500. https://doi.org/10.1016/j.joca.2018.01.018

Hayes, S. C., Newton, R. U., Spence, R. R., & Galvão, D. A. (2019). The Exercise and Sports Science Australia position statement: Exercise medicine in cancer management. *Journal of Science and Medicine in Sport*, *22*(11), 1175–1199. https://doi.org/10.1016/j.jsams.2019.05.003

Hickey, J. T., Opar, D. A., Weiss, L. J., & Heiderscheit, B. C. (2022). Hamstring Strain Injury Rehabilitation. *Journal of Athletic Training*, *57*(2), 125–135. https://doi.org/10.4085/1062-6050-0707.20

Jette, D. U., Hunter, S. J., Burkett, L., Langham, B., Logerstedt, D. S., Piuzzi, N. S., Poirier, N. M., Radach, L. J. L., Ritter, J. E., Scalzitti, D. A., Stevens-Lapsley, J. E., Tompkins, J., & Zeni Jr, J. (2020). Physical Therapist

Management of Total Knee Arthroplasty. *Physical Therapy*, *100*(9), 1603–1631. https://doi.org/10.1093/ptj/pzaa099

Kristiansen, J., Eddy, C., & Magnusson, S. P. (2024). Reliability and Validity of the End Range Hamstring Strength Test with Handheld Dynamometry. *International Journal of Sports Physical Therapy*, *19*(3). https://doi.org/10.26603/001c.94011

Kyritsis, P., Bahr, R., Landreau, P., Miladi, R., & Witvrouw, E. (2016). Likelihood of ACL graft rupture: not meeting six clinical discharge criteria before return to sport is associated with a four times greater risk of rupture. *British Journal of Sports Medicine*, *50*(15), 946–951. https://doi.org/10.1136/bjsports-2015-095908

Larson, D., Lorenz, D., & Melton, B. (2022). Can Clinician-Stabilization with Hand-Held Dynamometry Yield a Reliable Measure of Knee Flexion Torque? *International Journal of Sports Physical Therapy*, *17*(6). https://doi.org/10.26603/001c.37907

Lauersen, J. B., Andersen, T. E., & Andersen, L. B. (2018). Strength training as superior, dose-dependent and safe prevention of acute and overuse sports injuries: a systematic review, qualitative analysis and meta-analysis. *British Journal of Sports Medicine*, *52*(24), 1557–1563. https://doi.org/10.1136/bjsports-2018-099078

Lee, J. W. Y., Mok, K.-M., Chan, H. C. K., Yung, P. S. H., & Chan, K.-M. (2018). Eccentric hamstring strength deficit and poor hamstring-to-quadriceps ratio are risk factors for hamstring strain injury in football: A prospective study of 146 professional players. *Journal of Science and Medicine in Sport*, *21*(8), 789–793. https://doi.org/10.1016/j.jsams.2017.11.017

Malliaras, P., Cook, J., Purdam, C., & Rio, E. (2015). Patellar Tendinopathy: Clinical Diagnosis, Load Management, and Advice for Challenging Case Presentations. *Journal of Orthopaedic & Sports Physical Therapy*, *45*(11), 887–898. https://doi.org/10.2519/jospt.2015.5987

Martin, R. L., Cibulka, M. T., Bolgla, L. A., Koc, T. A., Loudon, J. K., Manske, R. C., Weiss, L., Christoforetti, J. J., & Heiderscheit, B. C. (2022). Hamstring Strain Injury in Athletes. *Journal of Orthopaedic & Sports Physical Therapy*, *52*(3), CPG1–CPG44. https://doi.org/10.2519/jospt.2022.0301

McGuigan, M. R., Wright, G. A., & Fleck, S. J. (2012). Strength Training for Athletes: Does It Really Help Sports Performance? *International Journal of Sports Physiology and Performance*, *7*(1), 2–5. https://doi.org/10.1123/ijspp.7.1.2

Medeiros, D. M., Aimi, M., Vaz, M. A., & Baroni, B. M. (2020). Effects of low-level laser therapy on hamstring strain injury rehabilitation: A randomized controlled trial. *Physical Therapy in Sport*, *42*, 124–130. https://doi.org/10.1016/j.ptsp.2020.01.006

Medeiros, T. M., Ribeiro-Alvares, J. B., Fritsch, C. G., Oliveira, G. S., Severo-Silveira, L., Pappas, E., & Baroni, B. M. (2020). Effect of Weekly Training Frequency With the Nordic Hamstring Exercise on Muscle-Strain Risk Factors in Football Players: A Randomized Trial. *International Journal of Sports Physiology and Performance*, *15*(7), 1026–1033. https://doi.org/10.1123/ijspp.2018-0780

Mendiguchia, J., & Brughelli, M. (2011). A return-to-sport algorithm for acute hamstring injuries. *Physical Therapy in Sport*, *12*(1), 2–14. https://doi.org/10.1016/j.ptsp.2010.07.003

MENDIGUCHIA, J., MARTINEZ-RUIZ, E., EDOUARD, P., MORIN, J.-B., MARTINEZ-MARTINEZ, F., IDOATE, F., & MENDEZ-VILLANUEVA, A. (2017). A Multifactorial, Criteria-based Progressive Algorithm for Hamstring Injury Treatment. *Medicine & Science in Sports & Exercise*, *49*(7), 1482–1492. https://doi.org/10.1249/MSS.0000000000001241

Morris, Norman. R., Hill, K., Walsh, J., & Sabapathy, S. (2021). Exercise & Sports Science Australia (ESSA) position statement on exercise and chronic obstructive pulmonary disease. *Journal of Science and Medicine in Sport*, *24*(1), 52–59. https://doi.org/10.1016/j.jsams.2020.08.007

Nascimento, L. R., Teixeira-Salmela, L. F., Souza, R. B., & Resende, R. A. (2018). Hip and Knee Strengthening Is More Effective Than Knee Strengthening Alone for Reducing Pain and Improving Activity in Individuals With Patellofemoral Pain: A Systematic Review With Meta-analysis. *Journal of Orthopaedic & Sports Physical Therapy*, *48*(1), 19–31. https://doi.org/10.2519/jospt.2018.7365

Ogborn, D., McRae, S., Larose, G., Leiter, J., Brown, H., & MacDonald, P. (2023). Knee flexor strength and symmetry vary by device, body position and angle of assessment following ACL reconstruction with hamstring grafts at long-term follow-up. *Knee Surgery, Sports Traumatology, Arthroscopy*, *31*(5), 1658–1664. https://doi.org/10.1007/s00167-021-06712-7

Opar, D. A., Williams, M. D., Timmins, R. G., Hickey, J., Duhig, S. J., & Shield, A. J. (2015). Eccentric Hamstring Strength and Hamstring Injury Risk in Australian Footballers. *Medicine & Science in Sports & Exercise*, *47*(4), 857–865. https://doi.org/10.1249/MSS.0000000000000465

Progression Models in Resistance Training for Healthy Adults. (2009). *Medicine & Science in Sports & Exercise*, *41*(3), 687–708. https://doi.org/10.1249/MSS.0b013e3181915670

Reurink, G., Goudswaard, G. J., Moen, M. H., Tol, J. L., Verhaar, J. A. N., & Weir, A. (2016). Strength Measurements in Acute Hamstring Injuries: Intertester Reliability and Prognostic Value of Handheld Dynamometry. *Journal of Orthopaedic & Sports Physical Therapy*, *46*(8), 689–696. https://doi.org/10.2519/jospt.2016.6363

Sharman, J. E., Smart, N. A., Coombes, J. S., & Stowasser, M. (2019). Exercise and sport science australia position stand update on exercise and hypertension. *Journal of Human Hypertension*, *33*(12), 837–843. https://doi.org/10.1038/s41371-019-0266-z

Sinacore, J. A., Evans, A. M., Lynch, B. N., Joreitz, R. E., Irrgang, J. J., & Lynch, A. D. (2017). Diagnostic Accuracy of Handheld Dynamometry and 1-Repetition-Maximum Tests for Identifying Meaningful Quadriceps Strength Asymmetries. *Journal of Orthopaedic & Sports Physical Therapy*, *47*(2), 97–107. https://doi.org/10.2519/jospt.2017.6651

Stark, T., Walker, B., Phillips, J. K., Fejer, R., & Beck, R. (2011). Hand-held Dynamometry Correlation With the Gold Standard Isokinetic Dynamometry: A Systematic Review. *PM&R*, *3*(5), 472–479. https://doi.org/10.1016/j.pmrj.2010.10.025

Swets, J. A. (1988). Measuring the Accuracy of Diagnostic Systems. *Science*, *240*(4857), 1285–1293. https://doi.org/10.1126/science.3287615

Timmins, R. G., Bourne, M. N., Shield, A. J., Williams, M. D., Lorenzen, C., & Opar, D. A. (2016). Short biceps femoris fascicles and eccentric knee flexor weakness increase the risk of hamstring injury in elite football (soccer): a prospective cohort study. *British Journal of Sports Medicine*, *50*(24), 1524–1535. https://doi.org/10.1136/bjsports-2015-095362

Vidmar, M. F., Baroni, B. M., Michelin, A. F., Mezzomo, M., Lugokenski, R., Pimentel, G. L., & Silva, M. F. (2019). Isokinetic eccentric training is more effective than constant load eccentric training on the quadriceps rehabilitation following partial meniscectomy: A randomized clinical trial. *Physical Therapy in Sport*, *39*, 120–125. https://doi.org/10.1016/j.ptsp.2019.07.005

Whiteley, R., Jacobsen, P., Prior, S., Skazalski, C., Otten, R., & Johnson, A. (2012). Correlation of isokinetic and novel hand-held dynamometry measures of knee flexion and extension strength testing. *Journal of Science and Medicine in Sport*, *15*(5), 444–450. https://doi.org/10.1016/j.jsams.2012.01.003

Whiteley, R., van Dyk, N., Wangensteen, A., & Hansen, C. (2018). Clinical implications from daily physiotherapy examination of 131 acute hamstring injuries and their association with running speed and rehabilitation progression. *British Journal of Sports Medicine*, *52*(5), 303–310. https://doi.org/10.1136/bjsports-2017-097616

Whyte, E., O'Connor, S., Tobin Jones, H., McBride, C., O'Flynn, A., Quinn, O., & Behan, F. (2024). The relationship between hamstring strength tests and sprint performance in female Gaelic footballers: A correlation and linear regression analysis. *PLOS ONE*, *19*(6), e0302901. https://doi.org/10.1371/journal.pone.0302901

Winter, E. M., & Fowler, N. (2009). Exercise defined and quantified according to the Système International d'Unités. *Journal of Sports Sciences*, *27*(5), 447–460. https://doi.org/10.1080/02640410802658461

Wollin, M., Thorborg, K., Drew, M., & Pizzari, T. (2020). A novel hamstring strain injury prevention system: post-match strength testing for secondary prevention in football. *British Journal of Sports Medicine*, *54*(9), 498–499. https://doi.org/10.1136/bjsports-2019-100707

Worrell, T. W., Perrin, D. H., & Denegar, C. R. (1989). The Influence of Hip Position on Quadriceps and Hamstring Peak Torque and Reciprocal Muscle Group Ratio Values. *Journal of Orthopaedic & Sports Physical Therapy*, *11*(3), 104–107. https://doi.org/10.2519/jospt.1989.11.3.104

4 CONCLUSÃO GERAL

O processo de desenvolvimento da presente dissertação envolveu uma série de discussões e o aperfeiçoamento de conceitos e ideias, e o produto deste estudo, após comparar 4 testes distintos da musculatura isquiotibiais com o dinamômetro isocinético, foi que os testes não apresentam correlação com o padrão ouro (testes A e B) ou uma correlação fraca (testes C e D). Além disso, à nossa principal análise estatística evidenciou que nenhum dos 4 testes apresentaram uma boa acurácia diagnóstica, ou seja, foram incapazes de detectar assimetrias de força. Do ponto de vista prático, nosso estudo ajuda os clínicos na tomada de decisão de escolha do melhor posicionamento de acordo com o objetivo da testagem. Ademais, apesar de pouco acessível, nosso estudo reforça a qualidade e a imprescindibilidade da utilização do dinamômetro isocinético.

5 IMPACTOS DO TRABALHO

A relevância que a musculatura isquiotibial, especialmente no âmbito da reabilitação de lesões musculo esqueléticas, como lesões musculares ou reconstrução de ligamento cruzado anterior, já é bastante consolidado. Além disso, a força muscular exerce um papel fundamental, desde a qualidade de vida até a alta performance, tornando a necessidade de mensurá-la ainda mais crucial. Nesse sentido, ao propormos a comparação entre testes de força isométricos com um dispositivo altamente acessível com o teste considerado padrão ouro, visando correlacioná-los, busca-se explorar a aplicabilidade desses achados no contexto clínico, esperando que esses resultados possam impactar diretamente os profissionais que atuam em clínicas de reabilitação, clubes de futebol e outros ambientes voltados à reabilitação, à promoção da saúde e ao desempenho físico. Assim, os resultados deste estudo auxiliam os profissionais na seleção do teste mais adequado para os objetivos específicos de cada paciente, a partir de um conjunto de opções disponíveis. Além disso, nossos achados fornecem aos clínicos uma compreensão mais precisa da acurácia e, especialmente, das limitações associadas à dinamometria isométrica dos isquiotibiais. Por fim, embora o Grupo de Ciência no Esporte e Exercício (GCEE) já atue nesse campo de pesquisa, o presente estudo identificou lacunas relevantes na literatura que ainda precisam ser preenchidas. Essas lacunas representam oportunidades para o envolvimento de mais estudantes e pesquisadores em estudos futuros, sempre com o objetivo de fornecer subsídios científicos que auxiliem os clínicos na tomada de decisões para o atendimento de seus pacientes.

ANEXOS

ANEXO A

Parecer de aprovação no comitê de ética

UNIVERSIDADE FEDERAL DE CIÊNCIAS DA SAÚDE DE PORTO ALEGRE

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Força Muscular e Desempenho Funcional de Atletas Amadores no Retorno ao Esporte Após Lesão Muscular de Isquiotibiais

Pesquisador: Bruno Manfredini Baroni

Área Temática:

Versão: 1

CAAE: 67187723.1.0000.5345

Instituição Proponente: Universidade Federal de Ciências da Saúde de Porto Alegre

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 5.949.807

Apresentação do Projeto:

As informações elencadas neste campo foram retiradas do arquivo Informações Básicas da Pesquisa PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_2081902

Objetivo da Pesquisa:

Verificar o desempenho de atletas amadores no período de retorno ao esporte após reabilitação de lesão muscular de isquiotibiais em testes de
força muscular e testes funcionais

Avaliação dos Riscos e Benefícios:

Riscos:

Os riscos à saúde dos voluntários durante as avaliações são mínimos, consistindo na sensação de cansaço físico e possibilidade de desconforto
muscular decorrente da realização dos testes de alta intensidade. Informamos que, no caso de ocorrência de qualquer lesão musculoesquelética
(estiramentos musculares, contraturas musculares e inflamações tendíneas) ou danos a tecidos biológicos em função do presente estudo, os
pesquisadores se responsabilizam por fornecer reabilitação fisioterapêutica completa e gratuita em consultório particular localizado na cidade de
Porto Alegre. Ainda, cabe ressaltar que qualquer eventual dano decorrente dos procedimentos

Endereço: Rua Sarmento Leite, 245, prédio 03, sala 605
Bairro: Sarmento **CEP:** 90.050-170
UF: RS **Município:** PORTO ALEGRE
Telefone: (51)3303-8804 **E-mail:** cep@ufcspa.edu.br

realizados no projeto de pesquisa será devidamente
indenizado.
Benefícios:
Em até 48 horas após a avaliação o voluntário receberá por e-mail o relatório de desempenho contendo os resultados obtidos na bateria de testes.
Este relatório não será fornecido a ninguém mais além do voluntário. Aconselhamos que este relatório seja encaminhado para o seu fisioterapeuta
responsável pela reabilitação do voluntário

Comentários e Considerações sobre a Pesquisa:

Conforme Informações Básicas do projeto na PB, trata-se de Estudo transversal observacional, nacional. Não randomizado. Caráter acadêmico, realizado para obtenção de título de mestre pelo Programa de Pós-Graduação em Ciências da Reabilitação. Número de 100 participantes incluídos no Brasil. Previsão de início em 01/04/2023 e encerramento do estudo em 30/08/2024.

Considerações sobre os Termos de apresentação obrigatória:

Pesquisador assistente e aluno de de Mestrado: Vinícius de Borba Capaverde, deve ser cadastrado na Plataforma Brasil como membro da equipe de pesquisa.

Recomendações:

Caso haja necessidade de adequação da metodologia, cronograma
entre outros, deverá ser encaminhada "emenda", dentro da vigência do projeto.

Conclusões ou Pendências e Lista de Inadequações:

Ressalta-se que nenhum dos documentos anexados à plataforma até este momento deverão
ser retirados, devendo, no caso de substituição, os novos documentos serem adicionados com o mesmo nome que foram incluídos na primeira vez, com a menção de "_versão 2", "_versão 3", e assim sucessivamente para nova avaliação do CEP.

Considerações Finais a critério do CEP:

Solicitar inclusão na Plataforma Brasil do pesquisador assistente como membro da equipe de pesquisa.

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação

Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_2081902.pdf	31/01/2023 11:11:09		Aceito
Folha de Rosto	folhaDeRosto_29Bruno_assinado.pdf	31/01/2023 11:10:58	Bruno Manfredini Baroni	Aceito
Projeto Detalhado / Brochura Investigador	Projeto.pdf	31/01/2023 07:38:57	Bruno Manfredini Baroni	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TA.pdf	31/01/2023 07:37:30	Bruno Manfredini Baroni	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE.pdf	31/01/2023 07:37:22	Bruno Manfredini Baroni	Aceito
Declaração de Pesquisadores	TCER.pdf	31/01/2023 07:36:43	Bruno Manfredini Baroni	Aceito
Declaração de Instituição e Infraestrutura	TARS.pdf	31/01/2023 07:36:25	Bruno Manfredini Baroni	Aceito

Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

PORTO ALEGRE, 17 de Março de 2023

Assinado por:
Fernanda Bordignon Nunes
(Coordenador(a))