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PHYSICAL AND TECHNICAL-TACTICAL PERFORMANCE IN JUDO ATHLETES WITH VISUAL IMPAIRMENTS: ANALYSIS FROM OFFICIAL COMPETITIONS AND VALIDITY OF A SPECIFIC PROTOCOL

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Tese submetida ao Programa de Pós-Graduação em Educação Física da Universidade Federal de Santa Catarina para a obtenção do Grau de Doutor em Educação Física

Orientadora: Profª. Drª. Daniele Detanico

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Rafael Lima Kons

PHYSICAL AND TECHNICAL-TACTICAL PERFORMANCE IN JUDO ATHLETES WITH VISUAL IMPAIRMENTS: ANALYSIS FROM OFFICIAL COMPETITIONS AND VALIDITY OF A SPECIFIC PROTOCOL

O presente trabalho em nível de doutorado foi avaliado e aprovado por banca examinadora composta pelos seguintes membros:

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Certificamos que esta é a **versão original e final** do trabalho de conclusão que foi julgado adequado para obtenção do título de doutor em educação física.

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Florianópolis, 2021

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Henrique José Kons e Raniere Lima Kons.

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RESUMO

O judô convencional ou para deficientes visuais é uma modalidade esportiva de combate caracterizada como intermitente e de alta intensidade. A única diferença da classe do judô para deficientes visuais em relação aos atletas convencionais é que os atletas são divididos em três grupos (além da categoria de peso) conforme o acometimento da visão, sendo estes: B1 – cego total, B2 – percepção de vultos e B3 – definição de imagens. Apesar dessa classificação existir, atletas das diferentes classes competem entre si, o que pode ocasionar desvantagem nos aspetos técnico-táticos e desempenho competitivo dos atletas com maior acometimento visual durante os combates. Além disso, pouco se sabe sobre a condição física em atletas de judô com deficiência visual, principalmente levando em consideração testes específicos, uma vez que alguns estímulos, como o tátil e o auditivo são compensados em função da falta total ou parcial do sentido da visão. A partir disso, esta tese foi dividida em três estudos cujo os objetivos foram: Estudo 1: (a) analisar o desempenho técnico-tático de atletas de judô com deficiência visual de alto nível de acordo com as diferentes classes esportivas a partir dos resultados dos Jogos Paralímpicos de Londres 2012 e Rio 2016; Estudo 2: (b) investigar a variação técnica e a performance competitiva nos Jogos Paralímpicos Rio 2016 de acordo com as classes esportivas e Estudo 3: (c) validar e adaptar o *Special Judo Fitness Test* (SJFT) para atletas de judô portadores de deficiência visual a partir de estímulos tátil e sonoro. Para os dois primeiros objetivos foram utilizados os livros de resultados dos Jogos Paralímpicos Londres 2012 e Rio 2016, os quais contêm resultados descritivos detalhados sobre o desempenho técnico-tático de cada atleta, juntamente com a classe esportiva individual. Para a validação e adaptação do SJFT, foram avaliados 20 atletas e 26 treinadores, das diferentes classes esportivas a partir de dois protocolos experimentais: estimulo tátil e sonoro, além de uma situação controle (sem estímulo). As análises estatísticas utilizadas nos estudos foram: Anova a um fator para verificar diferença das variáveis entre as classes, Qui-Quadrado para verificar associação entre as variáveis técnico-táticas, correlação de Pearson para verificar a relação entre o desempenho técnico-tático e a performance, índice de correlação intraclasse para verificar a reprodutibilidade dos diferentes protocolos do SJFT e regressão logística binomial para verificar a razão de chance de obter sucesso nas competições, de acordo com cada classe. Todos os testes consideraram um p-valor definido em 0,05. A partir do estudo 1 e 2, os resultados demonstraram que atletas com maior acometimento visual (B1) possuem menor desempenho nos aspectos de desempenho técnico-tático (e.g. scores, índice de eficiência) menores números de medalhas, e menor tempo para perder, comparado aos atletas com menor acometimento

visual (B2 e B3). Adicionalmente a razão de chance um atleta B1 obter medalhas variou de 3,0 a 7,2 menores comparados aos atletas B2 e B3. O desempenho da variação técnica também foi inferior para os atletas B1, principalmente nas variáveis de razão de vitória, variabilidade técnica e projeções por luta ($p<0,05$). Ainda, em relação ao terceiro estudo adaptação do SJFT nos estímulos tátil e sonoro demonstrou boa reprodutibilidade para ambas as adaptações, no entanto somente a adaptação sonora foi capaz de discriminar atletas de acordo com as classes visuais e também demonstrou ser a condição que os atletas apresentam o melhor desempenho nas variáveis do SJFT. Com base nos resultados das três investigações presentes nesta tese, podemos concluir que atletas com maior acometimento visual (B1) possuem menores desempenho comparado aos com menor acometimento visual (B2 e B3) e a adaptação do SJFT nos estímulos sonoros e táteis demonstrou boa reprodutibilidade, sendo o sonoro os estímulo em que os atletas obtiveram melhor desempenho.

Palavras-chave: Esportes de combate; Esporte paralímpico; Classificação; Desempenho competitivo; Reprodutibilidade

RESUMO EXPANDIDO

Introdução

O judô para atletas com deficientes visuais é uma modalidade pertencente ao programa de esportes paralímpicos, na qual foi inserido nos anos de 1988 para os homens e 2004 para as mulheres. De maneira geral, o judô para atletas com deficiência visual possui muita similaridade com a modalidade convencional, no entanto algumas diferenças podem ser evidenciadas como a adaptação na área de combate em competição, o estabelecimento da pegada no *judogi* (uniforme do judô) no momento inicial dos combates e uma divisão baseada nas classes visuais. Esta divisão é realizada com base em testes de visão de acuidade visual e campo visual e a partir deles, os atletas são classificados conforme o grau de deficiência, sendo: B1 – cego total, B2 – percepção de vultos e B3 – definição de imagens. Todos os atletas lutam juntos e isso implica diretamente no desempenho dos atletas com maior acometimento da visão, principalmente considerando aspectos de desempenho competitivo e técnico-tático. Em outra perspectiva, o desempenho físico também tem uma grande importância no âmbito competitivo, uma vez que já foi evidenciado que atletas de judô que possuem uma boa condição física, estão relacionados a bons resultados em competição oficial. Além disso, o monitoramento das capacidades físicas ao longo do processo de treinamento dos atletas de judô é algo fundamental, principalmente no ponto de vista de controle de carga de treinamento e na maximização do desempenho. No entanto, considerando atletas com deficiência visual e a falta de adaptação de protocolos específicos para atletas com deficiência, principalmente considerando os sentidos super compensados devido a falta da visão e critérios objetivos de validade, levando em conta o grau de deficiência visual ainda não foram explorados. A partir desta perspectiva, o objetivo da presente tese de doutorado foi analisar o desempenho técnico-tático de atletas de judô com deficiência visuais, considerando diferentes parâmetros de desempenho (ou seja, scores, variação técnica e estrutura temporal) e adaptar e validar um teste de judô especifico para atletas com deficiência visual.

Objetivos

O objetivos do presente tese foi dívida em três com base nos estudos realizados, sendo o primeiro analisar o desempenho técnico-tático de atletas de judô com deficiência visual de alto nível de acordo com as diferentes classes esportivas a partir dos resultados dos Jogos Paralímpicos de Londres 2012 e Rio 2016, o segundo investigar a variação técnica e a performance competitiva nos Jogos Paralímpicos Rio 2016 de acordo com as classes esportivas e validar e por fim adaptar o *Special Judo Fitness Test* (SJFT) para atletas de judô com deficiência visual a partir de estímulos tátil e sonoro. Os objetivos específicos são destacados conforme cada estudo, sendo os do primeiro estudo: comparar os scores, variação técnica e penalidades obtidas durante as partidas em judocas com deficiência visual de diferentes classes esportivas, comparar o índice de eficiência obtido durante as partidas em atletas com deficiência visual de classes esportivas e verificar a associação entre a variação técnica e a distribuição de medalhas nas diferentes classes esportivas. No segundo estudo, foram: Comparar os escores, variação técnica e penalidades obtidas durante as partidas em judocas com deficiência visual de diferentes classes esportivas, comparar o índice de eficiência obtido durante as partidas em atletas com deficiência visual de classes esportivas e verificar a associação entre a variação técnica e a distribuição de medalhas nas diferentes classes esportivas. Por fim, para o terceiro estudos, os objetivos específicos foram: Comparar o desempenho dos protocolos SJFT adaptados com estímulos sonoros e táteis e condição padrão em judocas com deficiência visual, testar a confiabilidade e sensibilidade dos protocolos SJFT adaptados com estímulos sonoros e táteis em judocas com deficiência visual e testar a validade de construto dos protocolos SJFT

adaptados para judocas com deficiência visual de diferentes classes esportivas (B1, B2 e B3) e nível competitivo (elite e não elite).

Metodologia

Para os dois primeiros estudos, foram utilizados os livros de resultados dos Jogos Paralímpicos Londres 2012 e Rio 2016, os quais contêm resultados descritivos detalhados sobre o desempenho técnico-tático de cada atleta, juntamente com a classe esportiva individual. Foram analisados os seguintes parâmetros extraídos dos livros: Scores, punições, tipo de medalhas obtidas, ações técnicas e suas variações e medidas de estrutura temporal considerando as três diferentes classes visuais (B1, B2 e B3). Para a validação e adaptação do SJFT (terceiro estudo), foram avaliados 20 atletas das diferentes classes esportivas a partir de dois protocolos experimentais: estimulo tátil (utilizando um linha de barbante colada com uma fita adesiva) e sonoro (som de palmas), além de uma situação controle (sem estímulo). Os atletas executaram o teste em um total de cinco vezes, sendo duas na situação de estimulo tátil, duas na situação de estimulo sonoro e uma na situação controle (sem adaptação). Para as adaptações, os atletas realizaram o teste em diferentes dias, com um intervalo mínimo de 24h com o intuito de verificar a reprodutibilidade do teste. Todas as situações foram realizadas de forma randomizada. Adicionalmente, 26 treinadores juntamente com os 20 atletas, responderam um pequeno formulário contendo questões relacionadas a utilização das adaptações dos testes e sua viabilidade em locais de treinamento de judô.

Resultados e Discussão

Os resultados dos dois primeiros estudos demonstraram que atletas com maior acometimento visual (B1) possuem menor desempenho nos aspectos de desempenho técnico-tático considerando os scores, índice de eficiência, menores números de medalhas de ouro, prata e bronze, e menor tempo para perder, comparado aos atletas com menor acometimento visual (B2 e B3). Adicionalmente a razão de chance um atleta B1 obter medalhas variou de 3,0 a 7,2 menores comparados aos atletas B2 e B3. O desempenho da variação técnica também foi inferior para os atletas B1, principalmente nas variáveis de razão de vitória, variabilidade técnica e projeções por luta. O sistema de classificação esportiva paralímpica atual mantem os atletas da mesma classe competindo juntos, os resultados destes dois estudos demonstram que além dos aspectos relacionados a obtenção de medalhas e vitórias, atletas com maior acometimento visual, possuem menores parâmetros de desempenho técnico-tático em competição de alto nível, sendo estes fatores um aspecto determinante para um bom desempenho em situações competitivas de alto nível. Ainda, em relação ao terceiro estudo a adaptação do SJFT nos estímulos tátil e sonoro demonstrou boa reprodutibilidade para ambas as adaptações, no entanto somente a adaptação sonora foi capaz de discriminar atletas de acordo com as classes visuais e também demonstrou ser a condição que os atletas apresentam o melhor desempenho nas variáveis do SJFT. Salientando que até o referido momento, o SJFT era utilizado apenas na avaliação dos atletas da modalidade convencional (sem deficiência) e é considerado um dos testes específicos mais utilizado ao longo de anos para avaliar a condição física de atletas de judô, sendo que o mesmo é capaz de discriminar atletas de diferentes níveis competitivos além de possuir boa relação com parâmetros neuromusculares e fisiológicos e também é um teste extremamente aplicável para avaliar e monitorar a condição física dos atletas ao longo de uma temporada de treinamento. Sendo assim, parece que as adaptações considerando os estímulos super compensados em atletas com deficiência visual demonstraram ser uma ferramenta valida e acessível para avaliar o desempenho físico especifico de atletas de judô com deficiência visual.

Considerações finais

A presente tese foi dividida em três estudos, na qual objetivou foi analisar o desempenho técnico tático de atletas de judô com deficiência visual de alto nível de acordo com as diferentes classes esportivas a partir dos resultados dos Jogos Paralímpicos de Londres 2012 e Rio 2016, o segundo investigou a variação técnica e a performance competitiva nos Jogos Paralímpicos Rio 2016 de acordo com as classes esportivas e o ultimo buscou a validação do (SJFT) para atletas de judô portadores de deficiência visual a partir de estímulos tátil e sonoro. Os principais resultados deste estudo sugerem que atletas de classes com maior acometimento visual tem um pior desempenho em diversos aspectos relacionados aos aspectos técnico-tático, demonstrando que o atual sistema de classificação paralímpica para atletas de judô não é legitima, uma vez que atletas com maior acometimento possuem clara desvantagem considerando o desempenho real da modalidade esportiva, algo que vem de encontro a uma das etapas na busca de evidências baseadas na classificação dos esportes paralímpico sugeridas recentemente, com o intuito de melhorar o sistema e tornar as disputas mais legitimas. Com base no terceiro direcionamento, podemos destacar que uma simples adaptação de um teste especifico já validado pela literatura, utilizando equipamentos de baixo custo, considerando estímulos sonoros e táteis de atletas com deficiência visual, é uma alternativa viável a ser utilizada na identificação de capacidades físicas especificas destes atletas, principalmente considerando o estimulo sonoro, na qual demonstrou um melhor resultado para os atletas de todas as classes.

Palavras Chaves: Esportes de combate; Esporte paralímpico; Classificação; Desempenho competitivo; Reprodutibilidade

ABSTRACT

Conventional judo or for athletes with visual impairment is a combat sport characterized as intermittent and with high intensity. The only difference from the conventional class (besides body weight category) is that athletes are divided into three groups according to vision impairment, being: B1 - total blindness, B2 - figure perception and B3 - image definition. Although the current classification system of the athletes from different classes competing together, this can often lead to a disadvantage on the technical-tactical aspects and competitive performance of athletes with greater visual impairment. Moreover, little is known about the physical assessment for visually impaired judo athletes, especially considering judo-specific tests, since some stimulus, such as tactile and sounds, are overcompensated due to total or partial lack of sight. From that, this thesis was divided into three studies whose objectives were: (a) analyze the technical-tactical and competitive performance of high level visually impaired judo athletes according to the different sports classes at the London (2012) and Rio (2016) Paralympic Games; (b) to investigate technical variation and competitive performance at the Rio 2016 Paralympic Games according to sports classes; and (c) validate and adapt the Special Judo Fitness Test (SJFT) for judo athletes with visual impairment based on tactile and sound stimuli. For the first two objectives, the London 2012 and Rio 2016 Paralympic Games results book was used, which contains statistics on the technical-tactical performance of each athlete. To validate and adapt the SJFT, twenty visual impairment judo athletes from different sports classes was evaluated based on two protocols: tactile and sound, besides a control situation (without stimulation). The follow statistical analyzes were used: Anova one-way to verify difference between classes, Chi-Square to verify association between technical-tactical variables, Pearson correlation to verify relationship between technical-tactical variables and competitive performance, intraclass correlation coefficient to test the reliability of different SJFT protocols and binomial logistic regression to verify the odds ratio of success in competitions according to each class. The Results showed that athletes with greater visual impairment (B1) have lower performance in technical-tactical performance aspects (eg scores, efficiency index), fewer medals, and less time to lose, compared to athletes with less visual impairment (B2 and B3), additionally the odds ratio for a B1 athlete to obtain medals ranges from 3.0 to 7.2 times lower compared to B2 and B3 athletes. The performance of the technical variation was also inferior for the B1 athletes, mainly in the variables of win ratio, technical variability and throws per match ($p<0.05$). Still, the adaptation of the SJFT in tactile and sonorous stimuli showed good reliability for both adaptations, however only the sonorous

adaptation is able to discriminate athletes according to visual classes and also proved to be the condition that athletes have the best performance in SJFT variables. Based on the results of the three investigations present in this thesis, we can conclude that athletes with greater visual impairment (B1) have lower performance compared to those with less visual impairment (B2 and B3) and the adaptation of the SJFT in sonorous and tactile stimuli demonstrated good reliability, being the sonorous stimulus in which the athletes obtained better performance.

Keywords: Combat Sports; Paralympic Sport; Visual Classification; Competitive performance; Reliability

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HR	Heart rate
SJFT	*Special Judo Fitness Test*
ICC	Intraclass Correlation Index
VO_{2max}	Maximum oxygen consumption
IPC	International Paralympic committee
IJF	International Judo Federation
IBSA	*International Blind Sport Association*
OBLA	Onset of blood lactate accumulation

SUMMARY

CHAPTER I

1. INTRODUCTION

Judo is an Olympic and Paralympic combat sport characterized as high-intensity intermittent actions, where the main objective is to throw the opponent, immobilizing him/her on the ground or leading him/her to give up through arm-locks or choke techniques (International Judo Federation – IJF, 2019; International Paralympic Committee – IPC, 2019). During judo competitions, in both modalities (Olympic and Paralympic), athletes perform three to five matches, with a maximum time of four minutes (if necessary, indeterminate time in the golden score), with a minimum 15-20 minute intervals between combats (IPC, 2017; IJF, 2017). One of the differences between the Olympic and Paralympic modalities is that in judo for athletes with visual impairment, there are the divisions that consider the three group classifications according to visual impairment, B1 – totally blind, B2 – perception of lights and B3 – definition of images. Another peculiarity is that in judo for the visually impaired, athletes already start the match in contact with the opponent's *judogi* (judo uniform) and have the help of referees to position themselves at the beginning of the match (IPC, 2017).

During judo combats, athletes perform multiple efforts in the constant search for an advantage, which are directly determined by technical, tactical, physical and psychological capacities (FRANCHINI et al., 2011a). One of the determinants of performance in competition are the technical-tactical performance parameters, which are analyzed based on the time-motion structure, frequency of attacks and defenses, technical variation and performance indices (FRANCHINI; ARTIOLI; BRITO, 2013). It was found that athletes with higher frequency of attacks actions during matches perform better in competitions with regard to the number of medals obtained and matches won (MIARKA et al., 2016a). In addition, these parameters have been used to discriminate winners and defeated athletes or winning and losing athletes (MIARKA et al., 2016b).

Considering the combats of the visually impaired judo athletes, it is believed that factors related to technical-tactical performance change due to low or no vision (KRABBEN et al., 2017; MASHKOVSKIY et al., 2019; KRABBEN et al., 2020; KRABBEN et al., 2021a; KRABBEN et al., 2021b). In this regard, Kons et al. (2018) compared the technical-tactical performance of the Olympic and Paralympic judo modalities and found that male athletes with visual impairment have less efficiency and scores when compared to conventional judo athletes analyzed from the Olympic and Paralympic Games (Rio 2016). These results demonstrate a

possible difference in the technical-tactical profile between the modalities, which is possibly related to the fact that conventional athletes have the visual field or visual acuity components and do not need the help of the referee to start the matches, as well as, other strategies for the grip moment in *judogi* that are used to counter the opponent. Moreover, Piras et al. (2014) found that athletes of higher competitive levels have different strategies in fixing the eyes at a given point, that is, advanced athletes fix their gaze on the opponent's chest and face for a short period of time, which precedes the execution of an action, while beginner athletes have more hand-directed vision and consequently, a longer time for subsequent action. This demonstrates that vision helps in many actions that determine a technical-tactical performance strategy in Paralympic judo.

A common characteristic of visually impaired athletes during matches is that they have the help of the referee to start the matches and to guide them after interruptions that occur during matches (IPC, 2018). In addition, an extremely relevant aspect in judo for visually impaired is that athletes from different sport classes (B1, B2 or B3) compete together, that is, only the division by weight category is considered and not by classification according to the involvement of the vision. As a result, athletes with greater visual impairment (i.e. B1) may be submitted to a disadvantage during matches when fighting against partially sighted athletes (i.e. B2 and B3). In addition, the vision, even partial, as observed in B2 and B3 classes, may be an important factor on technical-tactical performance in Paralympic judo, but it needs further investigation (PIRAS et al 2014; KONS et al., 2018).

There is limited evidence in literature that takes into account the technical-tactical performance in visually impaired athletes. The study conducted by Gutierrez-Santiago et al. (2011) analyzed the time-motion parameters during Paralympic judo matches. The authors found that combats in Paralympic judo tend to end before the regular time, as work sequences are shorter and pause sequences are longer, showing 12s of effort and 20s of pause, with the pause being superior to the conventional judo combat. This demonstrates that vision also influences the time-motion structure of matches. However, this study did not analyze the match-derived variables by comparing sport classes (B1, B2 and B3). Additionally, other important variables, such as time to achieve victory, time to defeat and time of actions related to moments of execution of techniques and scores should be explored considering the different sport classes.

When analyzing competitive performance parameters in athletes from different sport classes, Krabben et al. (2018) found that athletes from the B1 class have a lower percentage of medals compared to athletes from classes B2 and B3 in world championship judo competitions.

Furthermore, it was found that B1 athletes obtained from 1% to 4% of the medals won in the 2014 and 2015 world championships compared to B2 (27% and 29%) and B3 (24% and 19%) athletes. Linked to this, Mashkovskiy et al. (2019) found that athletes from the B1 class have had lower winning percentages over the last 10 years in official competitions compared to B2 and B3. In addition to B1, athletes had a lower winning percentage (20%) when confrontations occurred directly with athletes from classes B2 (60%) and B3 (62%). However, the literature considering technical-tactical performance parameters for the judo athletes with visual impairment according to the sport class is still incipient, requiring more detailed and in-depth analysis for a better understanding of these aspects.

In addition to the technical-tactical performance highlighted above, another major determining aspect in sports performance is the athletes' physical fitness. It has already been shown that the competitive performance (effectiveness, number of attacks and effective time) in conventional judo matches was explained in approximately 30% by physical abilities (anaerobic capacity, endurance strength in the upper limbs and muscle power in the lower limbs) (KONS et al., 2017). The physical capacities are usually measured and monitored during the training process over the competitive season (LOTURCO et al., 2017). To assist in this control, generic and specific tests are used in the assessments of judo athletes (DETANICO; SANTOS, 2012; FRANCHINI et al., 2011a; CHAABENE et al., 2018). The generic tests, for the most part, provide a better power to quantify physical capacity; however they have a lower ecological validity. The great advantage of specific tests is their ecological validity, but the disadvantage refers, in general terms, to the lower precision in the quantification of effort and in the determination of the physical capacities involved (CURRELL; JEUKENDRUP, 2008; CHAABENE et al., 2018).

In order to help coaches and physical trainers, some researchers have proposed specific judo-tests taking into account the specificity of the movements, and similarities with the physical demand of the judo matches (DETANICO; SANTOS, 2012). Among these, we can highlight the Special Judo Fitness Test (SJFT) proposed by Sterkowicz (1995) and described by Franchini et al. (1998), in which it identifies the aerobic and anaerobic capacity of judo athletes from a specific movement (*ippon seoi-nage*). The SJFT was validated by Sterkowicz et al. (1999) being one of the most used in recent decades (STERKOWICZ-PRZYBYCIEN; FUKUDA; FRANCHINI, 2019). In addition, the SJFT has excellent reliability for the number of throws (FRANCHINI et al., 1999) and construction validity, as it can discriminate athletes of different competitive levels from the total throws and index (FRANCHINI et al., 2005).

In the judo modality for the athletes with visual impairment, few investigations have analyzed physical performance parameters in this population and none of them using specific judo tests. We can cite the study conducted by Karakoc (2016) who found that conventional judo athletes have higher levels of muscle strength and power in the upper and lower limbs compared to visually impaired athletes. Loturco et al. (2017a) verified that athletes of both modalities (Brazilian team of Olympic and Paralympic judo) have similar absolute strength levels, differing only in the parameters of lower limb muscle power. Another study analyzed the effect of traditional judo training on muscle power levels of upper limbs (bench press exercise linked to a load cell) and lower limbs (vertical jump with barbell) in Paralympic judo athletes (LOTURCO et al., 2017b).

The lack of specific assessments in the judo for visually impaired, opens a gap in literature and in the sports fields. It is possible to consider that there is still a lack of tests or adaptations to access physical judo performance in this population. The specific tests proposed for judo were structured and validated only for athletes of the conventional modality, since it is already known that people with visual impairment have their senses of hearing and touch compensated due to the lack of visual perception (SHIOTA and TOKUI, 2017; THEODOROU et al., 2013). Therefore, it is believed that the SJFT can be used to assess physical performance of judo athletes with visual impairment through an adaptation to sonorous and tactile stimuli. Still, testing the construct validity for different sport classes (B1, B2 and B3) will indicate whether the SJFT can be used regardless of the degree of vision impairment.

Therefore, considering that there is a lack of information related to the technical-tactical and competitive performance of judo athletes with visual impairment, especially according to each sport class and in addition to the lack of an adapted protocol to measure the specific physical capacities for these athletes, the following research questions were formulated: (a) is there a difference in technical-tactical performance (time-motion structure, technical variation and competitive performance) among visually impaired judo athletes allocated in different sport classes?; (b) would the adaptation of the SJFT, from tactile and sonorous stimuli, provide better performance for judo athletes with visual impairment when compared to the conventional test?; (c) could the adapted SJFT be used for different sport classes (B1, B2 and B3)?

2. OBJECTIVES

2.1 Study 1

General Objective

The general objective of the present study were to analyze the technical-tactical and competitive performance of high-level judo athletes with visual impairment according to different sports classes from the London 2012 and Rio 2016 Paralympic Games

Specific objectives

- Compare the scores, technical variation and penalties obtained during the matches in judo athletes with visual impairment from different sports classes.
- Compare the efficiency index obtained during matches in athletes with visual impairment from sport classes.
- Verify the association between the technical variation and the distribution of medals in different sport classes.

2.2 Study 2

General Objective

The general objective of the present study were to investigate the technical variation and competitive performance at the Rio 2016 Paralympic Games according to sports classes.

Specific objectives

- Compare the time-motion variables obtained during judo matches in athletes with visual impairment from different sports classes.
- Identify the relationship between technical variation and win ratio in judo athletes with visual impairment.

2.3 Study 3

General Objective

The general objective of the present study were to test the reliability, sensitivity and construct validity of the SJFT for judo athletes with visual impairment based on adaptations with tactile and sonorous stimuli.

Specific objectives

- Compare the performance of SJFT protocols adapted with sonorous and tactile stimuli and standard condition in judo athletes with visual impairment.
- Test the reliability and sensitivity of the SJFT protocols adapted with sonorous and tactile stimuli in judo athletes with visual impairment
- Test the construct validity of the SJFT protocols adapted for judo athletes with visual impairment from different sport classes (B1, B2 and B3) and competitive level (elite and non-elite).

3. HYPOTHESES

3.1 Study 1

1. Athletes with greater visual impairment, classified as B1, would present worse technical-tactical parameters and lower efficiency during official matches when compared to athletes with less impaired vision (B2 and B3).

3.2 Study 2

1. Athletes with greater visual impairment would have a lower win ratio and technical variation compared to athletes with less visual impairment.

3.3 Study 3

1. Both SJFT adaptations through sonorous and tactile stimuli would present better reliability than the standard test.
2. Both SJFT adaptations could be used for judo athletes with visual impairment regardless of the degree of impairment considering the validity parameters.

CHAPTER II

4. LITERATURE REVIEW

4.1 Evidence-based on sport classification in Paralympic judo

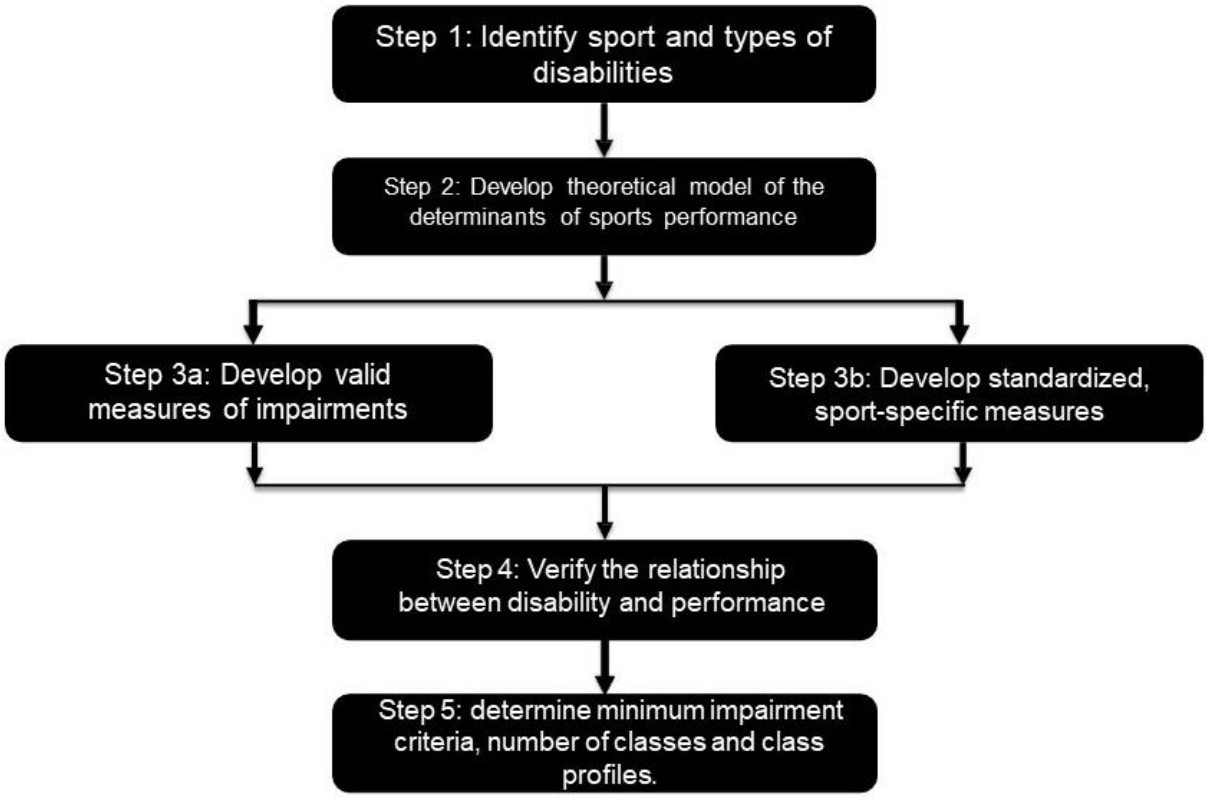
The main objective of the classification in Paralympic sports is to promote the participation in sport for people with disabilities and equality providing between the competitors, minimizing the disadvantages that may occur in the final results and throughout the sport competition (TWEEDY; VANLANDEWIJCK, 2011; MANN; RAVENSBERGEN, 2018). If a specific system classification whether physical, intellectual or visual achieves this goal, each class in which each athlete will compete must consist of athletes with different disabilities that cause approximately the same advantage/disadvantage ratio in a particular sport. This will consequently create a structure for a competition in which athletes who succeed in their competition/match will be those who have the most advantageous combination of skills in that sport, directly related to anthropometric, physiological, neuromuscular and psychological parameters that have been improved during the training process (TWEEDY; VANLANDEWIJCK, 2011; MANN; RAVENSBERGEN, 2018).

Organizations that manage the sports in which an athlete can compete in the Paralympic Games are different, for example, for a sport in which athletes are visually impaired; (*e.g.* judo, five-a-side soccer and goalball) the International Blind Sport Association (IBSA) is responsible for conducting the organization of the competition rules and the classification process, while for athletes from other Paralympic sports there is an organization for each modality. As an example, wheelchair fencing is organized by the International Wheelchair and Amputee Sports Federation and Para-Taekwondo is organized by the World Taekwondo Federation. For the most part, Paralympic sports have a single body that organizes only one modality, unlike other sports in which only the athletes with visual impairment participate and are organized by the IBSA.

Based on these aspects, one of the research priorities of the Visual Impairment Classification Research and Development Center is to facilitate the development of sport-specific systems for classifying athletes with visual impairment (Figure 1). For example, it might be reasonable to expect that, given the contrasting visual demands of different sports, even a mild level of visual acuity impairment can have a significant impact on performance in some sports (*e.g.* soccer and alpine skiing) (TWEEDY; VANLANDEWIJCK, 2011), but has

less impact on others (*e.g.* swimming and judo) (TWEEDY; VANLANDEWIJCK, 2011). Sport-specific rating systems would reflect the relative importance of visual acuity in these sports. In summary, there are a variety of Paralympic sports and the types of disability eligible for these sports vary considerably (TWEEDY; VANLANDEWIJCK, 2011; MANN; RAVENSBERGEN, 2018).

Figura 1. Flowchart of the different steps to develop evidence-based systems in the classification of Paralympic sport



Source: Adapted from Mann e Ravensbergen (2018)

Although this system has been implemented and some changes to the sport-specific classification have progressed in sports that cater to athletes with physical and intellectual disabilities, most sports for athletes with visual impairment continue to use a long-standing system that employs the same class structure regardless of the sport. Currently, athletes who have visual impairment are allocated to one of three different sport classes (B1, B2 or B3) that differ according to the impairment of vision (MANN; RAVENSBERGEN, 2018). These criteria were developed based on the World Health Organization – WHO definitions of low vision and blindness (WHO, 2004).

The current system was recently evaluated by a panel of experts in thirteen different sports that have classes or athletes with visual impairments (RAVENSBERGEN et al., 2016). These experts reached a consensus that the existing sport classification procedures for disabled people do not achieve the objective of minimizing the impact of impairment on sports performance, with the lack of specificity of the sport being the main limitation. Subsequently, a position paper specific to visual impairment was formulated and adopted by the IPC and the IBSA. This position describes the appropriate approaches for conducting research on the relationship between impaired vision and performance in sports for people with visual impairments (MANN; RAVENSBERGEN, 2018). According to expert consultations, the response stand for sports with visual impairment highlighted the need for research specificity of each sport that relates to Paralympic classification. The main sports-specific decisions that need to be made are: (i) what aspects of vision should be measured, (ii) how performance should best be measured in the specific sport, and (iii) under what conditions should vision testing take place.

Table 1 presents the description of each proposed vision test used to classify athletes in the sports of soccer 5, goaball, swimming and judo. All tests take into account medical criteria for the classification and allocation of athletes according to the established classes (B1, B2 and B3), without taking into account the specificity of the sport.

Table 1. Description of each proposed vision test to use in sports classification in people with visual impairments

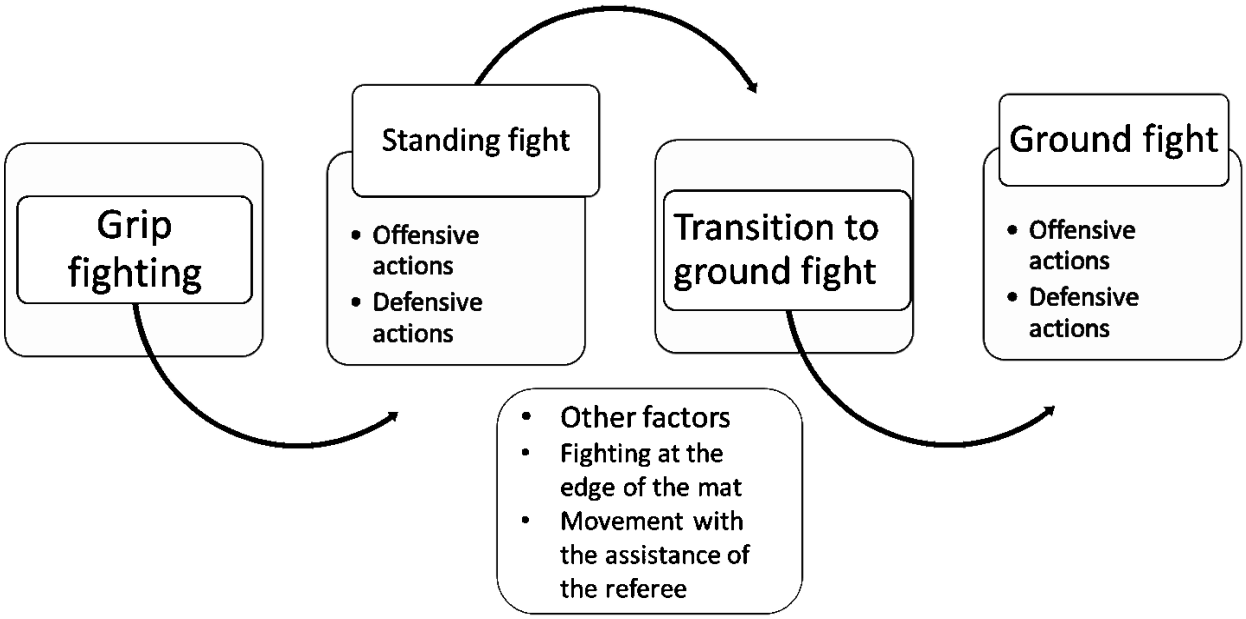
Vision tests	Description
Visual acuity	A measure of the sharpness/clarity of vision
Visual field	A measure of the area of peripheral vision with which an individual can see (i.e., without moving their eyes)
Motion perception	The ability to estimate the speed and the direction of a moving object
Dynamic visual acuity	A measure of the sharpness/clarity of vision when observing a moving target
Light sensitivity	The impact of bright lights on the ability to see clearly
Ocular coordination	The ability of both eyes to move together in cooperative fashion

Depth perception	The ability to perceive the world in three dimensions, e.g., to estimate the distance to an object
Contrast sensitivity	The ability to distinguish objects from a background
Color vision	The ability to distinguish different colors

Among the sports that are classified based on visual acuity and visual field (at the moment), these tests are controversial in their classification process in judo for the visually impaired, although athletes are allocated in one of three classes (B1, B2 and B3), as in most other sports for the athletes with visual impairment, during the competition all athletes compete with each other, regardless of the allocated class. Thus, effectively, judo for the athletes with visual impairment has only one sport class, with all athletes competing against each other, regardless of whether they are partially or completely blind. Blind athletes do not receive advantages or disadvantages during competition, with classes used solely for the purpose of allocating classification points to the world classification list based on the results of each match.

The logic behind this historic choice of having a single competition in which athletes of all classes compete is that adaptations to competition rules in visual impairment judo increase the likelihood that those with more impairment will not be harmed by competing against others with less impairment (KRABBEN et al., 2018; KRABBEN et al., 2020). In conventional judo, athletes start their fight with approximately 4 m of distance and a dispute begins for a better grip on the *judogi*, and after this contact, the action process begins to try to counteract each other. Due to the presumably high visual demands of this fight for the *judogi* grips (PIRAS et al., 2014; KRABBEN et al., 2020; KRABBEN et al., 2021a), athletes with visual impairment already start combats with the pre-established *judogi* grip. Figure 2 describes the combat process of judo athletes with visual impairment.

Figura 2. Judo combat model for the visually impaired during matches.



Source: Adapted from Krabben et al. (2019)

Exemplifying in detail Figure 2, the athletes with visual impairment starts the fight with the grip established in the *judogi*, later, the athletes try to obtain an advantage over the opponent. They then proceed to the standup fight, in which one of them will try to unbalance and throw (offensive actions), while the other will try to avoid being thrown (defensive actions). After a throw there is a continuous dispute with a progression on the ground. During the transition from standup to ground fighting, the athlete must quickly adapt to start the fight from an advantageous position. During the fight, the athlete must have the objective of scoring by fixing or submitting the opponent (offensive actions) and the opponent must prevent the opponent from performing points (defensive actions). If no progress in the fight on the ground is made within a reasonable period of time, the referee will pause the fight and assist the athletes to get up, in which they return to the start of the fight, with the initial grips until the referee's command to restart the combat. During breaks in the fight, coaches can give instruction regarding the score and time remaining in the combat.

One of the main differences from the conventional sport is that visually impaired athletes already start combat with the established grip in the *judogi*, as shown in Figure 3. This adaptation presumably reduces the visual demands of the sport, making it more suitable for people with visual impairment, offering the opportunity to rely heavily on other sources of information (*e.g.* tactile, kinesthetic and auditory senses). However, it is doubtful that the adaptations to the rules will be sufficient to allow judo athletes with different degrees of visual

impairment to fight equally against each other. Recent analyzes of judo official competitions suggest that in the current system blind judokas may be at a disadvantage when competing against partially sighted opponents (KRABBEN et al., 2017; MASHKOVSKIY et al., 2018; KRABBEN et al., 2020). However, no studies have been carried out that directly relate to measures of functional vision and performance in judo. This information is necessary to determine how many classes are guaranteed for judo athletes with visual impairment to compete and how the range between visual classes should be defined (TWEEDY; VANLANDEWIJCK, 2011; MANN; RAVENSBERGEN, 2018).

In judo, some researchers (KRABBEN et al., 2018; KRABBEN et al., 2019; KRABBEN et al., 2020) have sought, based on these aspects, to direct a new sport classification system, to be implemented in a few years in the judo modality with visual impairment, especially considering the aspect of the disability of the most visually affected athletes. This survey has been carried out with the support of the IPC, precisely to try to modify over the years the classification rules of the sport to make the competition system fairer and more accessible for all athletes with disabilities.

Krabben et al. (2019), from a panel of experts in the judo modality for judo athletes with visual impairment, in which 18 high-level judo athletes, three managers, seven judo coaches, two visual classifiers and 3 referees participated in order to answer questions divided into 10 aspects: (1) related to the objective of classification in judo for athletes with visual impairment; (2) the minimum criteria of inequality; (3) sports classes; (4) the vision tests used to classify athletes; (5) in relation to the impact of vision on sport performance; (6) current conditions of vision tests; (7) impact of visual impairment on different weight categories; (8) impact of a congenital disability versus acquired vision loss; (9) regarding the use of sales during combats; (10) intentional misrepresentation. Table 2 describes the percentages of expert opinions based on yes (they are in agreement with the current system) or no (they are not in agreement with the current system).

Table 2. Expert opinion on aspects related to the classification and performance of judo for the visually impaired (Souce: KRABBEN et al., 2019).

Panel	Question	Yes (%)	No (%)	Partial (%)
1. Aim of classification	Do you believe that the way that vision impairment is currently	17	61	22

	classified within judo athletes with visual impairment fulfils the aim to minimise the impact of vision impairment on the outcome of competition?			
2. Minimum impairment criteria	Is more research needed to define the minimum level of visual impairment that would decrease judo performance?	80	20	
3. Sport classes	Do you believe that the current point system helps judokas with more severe vision impairment to qualify for the Paralympic Games?	81	19	
4. Measures of visual function to be used during classification	Do you believe that the assessment of visual acuity and visual field are the only measures of visual function that should be used for classification in judo athletes with visual impairment	42	58	
5. Impact of vision impairment on different aspects of performance	For the following aspects of judo performance, please indicate how important you believe they are for winning a match in judo athletes with visual impairment	Offensive Strategies in Standing Combat (69%)	Attempts to understand the combat score (25%)	Other aspect (6%)
6. Vision testing conditions	Would you be in favour of the use of centralized classification centres instead of classification being held at competition venues?	76	24	
7. Impact of vision impairment across different weight categories	Do you believe that vision impairment is more likely to impact the performance of lightweight judokas than it would for heavyweight judokas?	56	44	

8. Impact of a congenital compared to an acquired impairment	Do you believe that the age at which a vision impairment is acquired should be taken into account during classification?	76	24	
9. The use of blindfolds	Do you believe that the use of blindfolds would be an appropriate way to create fair competition in judo athletes with visual impairment ?	31	69	
10. Intentional misrepresentation	Do you believe that some judo athletes with visual impairment are currently intentionally misrepresenting their level of visual ability during classification?	94	6	

The research results showed relevant findings related to judo athletes with visual impairment. We observed some key points related to research in relation to the minimum impairment criterion, which still needs more evidence considering the judo modality. In the classification system of athletes at an international level of competition, in which, due to the visual classification, some athletes end up at a disadvantage and in turn end up not being classified in international competitions, as they have already suffered defeat in national levels of competition and finally intentional misrepresentation, whereby some athletes intentionally mislead the system so that they are classified as visually impaired and thus end up competing with greater advantage.

The use of blindfolds is also a point that deserves to be highlighted, although other sports for the visually impaired use blindfolds during competitions (MANN and RAVENSBERGEN, 2018) we can cite this in an example wthin goalball, in which the classification system is exactly the same as judo, but all athletes wear blindfolds during the games. The opinions of experts do not seem to go against its use in judo combats. The use of blindfold athletes with lower visual acuity would be at a disadvantage, because they are not adapted to use them in training and also because of discomfort it could cause in the ocular region (KRABBEN et al., 2019), although it has already been shown that the use of blindfolds decreases performance when compared to combat without blindfolds (KRABBEN et al., 2020). Krabben et al (200) considering the situations that increasing levels of simulated vision impairment verify that performance in a

visually guided combat-sport task is resilient to high amounts of blur. This perspective presumes which skilled athletes are able to maintain performance under suboptimal visual conditions, even in highly visually demanding perceptual-motor tasks (the case of judo grip).

4.2 Technical-tactical and competitive performance in conventional and Paralympic judo

Technical-tactical analysis in combat sports can be used to understand the way in which sport skills are performed during official competitions, which can provide important information during annual competitive planning. Analyzing the profile of judo athletes is important to understand how they use their techniques in the competition environment, in an attempt to obtain an advantage over an opponent (FRANCHINI et al., 2008). A lot of emphasis is established on the coach's ability to observe and analyze technical aspects considering competitive performance. However, this becomes difficult during judo combat, as athletes constantly change their movements, in an attempt to increase the advantage of their actions, in order to make it difficult for the opponent to perform a throwing technique (CALMET; AHMAIDI, 2004). One of the possibilities to evaluate judo athletes in the competition environment is through the filming of judo combats in competitions. With the recorded videos, three ways of evaluating performance are attributed: a) competitive performance (percentage of victories, efficiency indices, effectiveness and scores); b) temporal structure of the athletes during the matches; c) technical variation (ADAM et al., 2013; ADAM et al., 2012; MIARKA et al., 2012; MIARKA et al., 2014).

Several studies have used these indices to assess performance in elite athletes and found that among these athletes, attack effectiveness indices vary between 5.0% and 28.6%, while defense effectiveness indices vary between 96.9 and 100% in national and international competitions, respectively (ADAM et al., 2012; ADAM et al., 2013; ADAM et al., 2011). In addition to the effectiveness indices, another way to quantify the performance in competition is to use the index attack efficiency (IAE), which considers the scores obtained by the number of competitions (ADAM; SMARUJ; TYSZKOWSKI, 2011), according to the equation 1.

$$Index\ of\ attacks\ efficency\ \frac{(7xNW) + (10xNI)}{number\ of\ competitions} \quad \text{(Equação 1)}$$

Where:

NW= Number of wazaris obtained in competitions (average judo score)

NI= Number of *ippon* obtained in competition (maximum judo score)

Regarding technical variation, judo is a modality composed of different groups of throwing and finishing techniques on the ground. Techniques are classified as Te-waza, where the predominance of attacks and defenses are from the arm, Koshi-waza (hip), Ashi-waza (legs) and Sutemi-waza (sacrifice). On the ground there are three groups of techniques, immobilizations are classified as Osae-komi-waza, strangulation (shime-waza) and joint-lock (kansetsu-waza) techniques. Considering these classifications, there are 94 officially recognized techniques, 67 projection techniques and 27 mastery techniques (FIJ, 2016).

The analysis of the temporal structure is another way to quantify the judo fight, considering the relations of effort and pauses. It is known that the judo fight lasts a total time of four minutes (official time according to the rules modified in 2017), and may extend up to an indefinite time (Golden score). During these times, there are several breaks, where the time of an attack or defense in combat moments can be computed, or the total work time in the standing fight and on the ground fight. The temporal analysis allows us to infer this information about the specific effort of the judo fight required during combats. Some important aspects must be taken into account when analyzing the temporal structure variables:

a) Total combat time: comprises the period of time in which the referee started (hajime), interrupted (mate) and ended the combat (soremade);

b) Standing fight time: comprises the period in which one or both fighters performed the work of throwing techniques to the ground (nage-waza) provided for by the rule;

c) Gripping time: comprises the time in which the athletes remained executing the grip (kumi-kata) without the execution of techniques;

d) Displacement time without contact: comprises the period in which the referee announced the start of the combat (hajime) until the execution of the grip (kumi-kata);

e) Ground fight time: comprises the period in which one or both fighters performed ground techniques (ne-waza), provided for by the rule;

f) Pause time: the recovery time that comprises the period between the combat stop signal (mate) and the combat restart signal (hajime command voice). Commands to stop the fight (sonomama, stays without moving) and restart (yoshi) are also computed as recovery (MIARKA et al., 2014).

One of the most relevant studies in the literature is that of Castarlenas and Planas (1997), which identified activities of 18.0 ± 8.5 seconds and intervals of 12.4 ± 4.1 seconds during the senior world championship in 1991. Miarka et al. (2012) evaluated the temporal structure of

1811 official judo matches in athletes of different age groups: pre-juvenile (13-14 years), juvenile (15-16), junior (17-19) and senior (>20 years) during three regional competitions and one state competition. The combats were evaluated using the FRAMI® software (MIARKA et al., 2010). The results showed that the junior category matches ended in 44% of the total fight time, while the senior category ended in 56% of the match duration. The match time was 19% of the fight time for junior athletes and 28% for senior athletes. Additionally, the break time was the same in both categories, 14% for junior athletes, while 17% was reported for the senior. The findings also showed that 29 matches in the junior category and 145 matches in the senior category made extra time (golden score).

In judo for athletes with visual impairment, some studies were carried out taking into account (a) temporal structure during combats (b) competitive performance (c) influence of using a "blindfold" to verify the role of vision in performance, these studies will be detailed above.

Gutierrez-Santiago et al. (2011) verified from a detailed analysis from an official competition of judo athletes with visual impairment, the temporal actions of athletes, and compared these actions between male and female athletes without subdividing by classes. The main results showed that the total fight time was 266s for men and 242s for women, break time being between 158 and 172s, while the action time during combats was 82s and 54s, in addition to the sequence time of the activity ranged between 19s for male and 21s for female. In addition, the fight time, action time in combat was statistically higher for male athletes, thus giving some indications of monitoring and training prescription based on these results.

In order to verify differences in the temporal structure between the judo modality with visual impairment and the conventional, Gutierrez-Santiago et al. (2011) compared the results found in their previous study, with the results found by other studies in which they verified the temporal structure of judo athletes in the conventional modality. The author found that the total combat time was longer for athletes in the conventional modality (172s) compared to athletes with visual impairment (130s), additionally the pause time to perform a technique sequence was shorter for athletes of the conventional modality (12s) compared to athletes with visual impairment (19s) and finally the work sequence time was also longer for athletes with visual impairment (22s) compared to the conventional modality (18s). This data provided important indicators related to the difference in the temporal structure between the modalities and consequently the difference in some aspects due to the lack of vision. However, the author did

not consider the difference within the sport classification in judo athletes with visual impairment.

Another study that sought to compare athletes between conventional sports and those for the visually impaired was the one by Kons et al. (2018) which, based on the results of the Olympic and Paralympic Games Rio 2016, verified aspects related to scores, penalties and efficiency indices between the two modalities. Significant differences were found in the percentage of wazari (score) and shido (penalty), being higher for the conventional modality, however the percentage of ippon was significantly higher for the judo modality for athletes with visual impairment. This result is in line with the different strategies used by athletes to obtain victories in high-level competition, as conventional athletes have the mechanism of vision during combats, thus, they can obtain victories by advantages from lower scores (for example, wazari) or forcing the opponent to receive penalties strategies that cannot be adopted by athletes with visual impairments.

In order to test the role of vision in the performance of judo athletes, Krabben et al (2018) carried out an experiment in which they placed conventional athletes to perform simulated matches in two situations, one with fully blindfolded and the other without the blindfolded. The matches were performed so that one of the evaluated athletes was blindfolded while the other was not, thus, all of the athletes were evaluated in both situations. In this study, the number of throws occurred in each combat and the total number of scores of each combat were analyzed. The results showed that during the blindfolded experiment, the athletes had fewer throws and scores over the combats, thus demonstrating the importance of vision for obtaining scores and for better performance during judo combats.

Recently, another aspect that has been investigated is in relation to the performance of athletes with visual impairment. However, subdivided into different sporting classes (B1, B2 and B3), Krabben et al. (2018) found that B1 athletes had lower than expected medal counts obtained during the 2014 and 2015 world competitions compared to B2 and B3 athletes. It is worth noting that it was found that B1 athletes obtained only 2% and 8% of the medals, compared to 27% and 29% of B2 athletes and 24% and 19% of B3 athletes. It is clear from these data that athletes with greater visual impairment are less likely to win medals in international competitions, especially during the 2014 and 2015 timeline.

Associated with these aspects and considering the performance over the time for athletes with visual impairments, Mashkovskiy et al (2018) found that over the 10 years, in which world judo championships occurred, B1 athletes had a percentage of 25% of winning (in

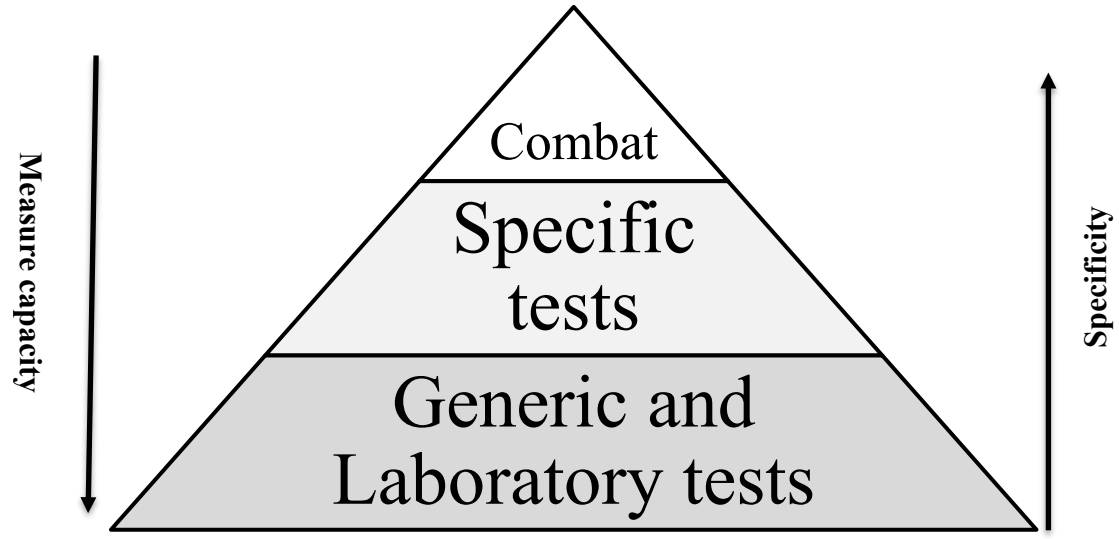
the year 2007), with a decrease of 6% in 2017. Athletes B2 and B3 managed to maintain between 50 and 35% of the fight winnings over the 10 years analyzed, and this demonstrated that over a longer timeline, B1 athletes remained at a disadvantage compared to other classes, and this disadvantage has increased over the years.

Clearly, it is possible to note that the classification in judo for the visually impaired ends up favoring some athletes whose vision impairment is lower, resulting in worse results in competitions over the years, however it is worth noting that these studies have only pointed out issues related to percentage of medal victories and winnings. It is worth mentioning the lack of information regarding the performance and technical-tactical strategies of athletes with visual impairment and also the possible differences between the classes will support the process of classification of the sport and establish strategies for training and new evidences based visual judo classifications considering the physical/technical tactical performance in judo athletes with visual impairment.

4.3 Validity and Reliability of Physical Tests

Over the last few decades, several laboratory and field tests have been developed in order to assess the physical performance of athletes, whether from individual, team and combat sports. When we attempt to assess and analyze athletes who are part of an individual modality specifically combat sports, generic tests or laboratory tests, despite them providing important data on the physical condition and physiological/neuromuscular characteristics of athletes in general, the tests do not present as most suitable. These tests are considered incapable of reproducing some actions related to the combat sports, as they do not take into account specific motor gestures of the modality, considering the high complexity of combat sports. Figure 3 shows a hierarchical pyramid in which the relationships between physical tests and the main task are established. In the case of combat sports, it is noted that the more specific the assessment is, the closer it is to the realities of the combats (external validity), however, the more distant from specificity, which in this case would be generic and laboratory tests, the better the accuracy of measuring physical capacities (internal validity).

Figura 3. Relationship between physical tests and proximity to the main task (combat)

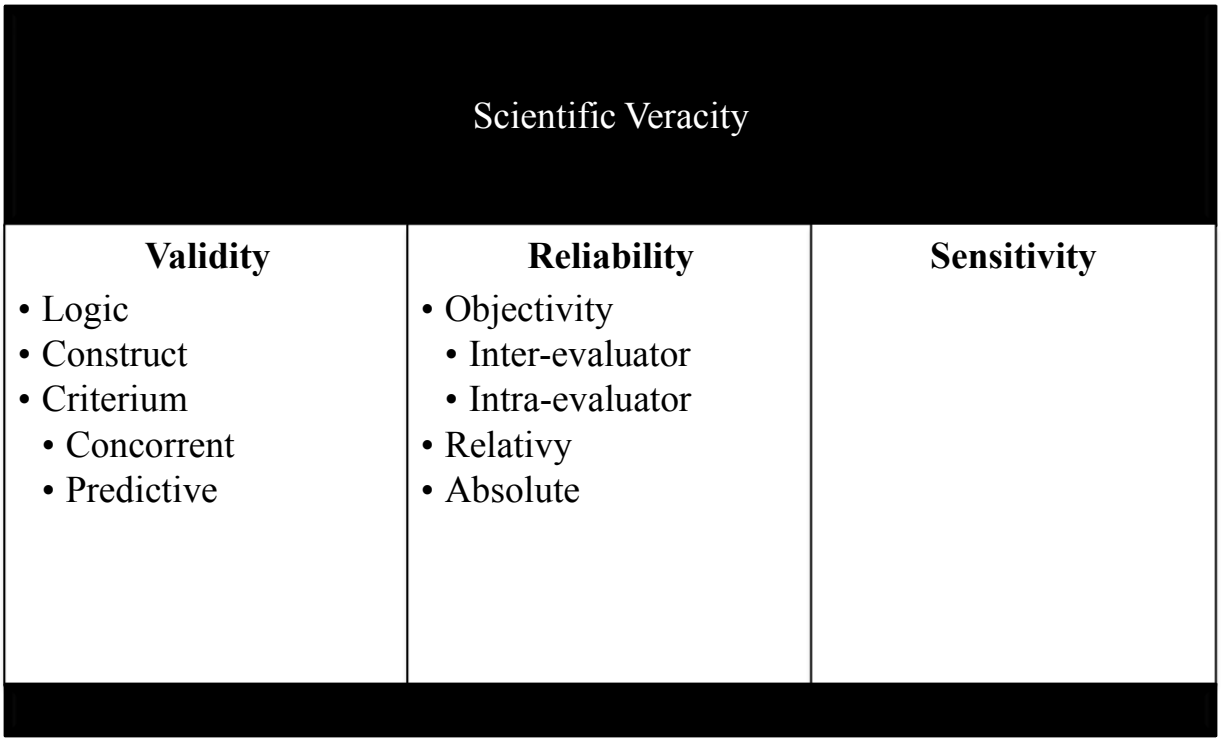


Source: Autor

Thus, some researchers have sought to validate some specific protocols for combat sports, taking into account the motor gesture and some specific demands of the modality (CHABEENE et al., 2018). To establish the veracity of these assessments, researchers need to follow some criteria already present in the literature, which will provide consistency and support in relation to the use of the test in different conditions/phases of the athlete's preparation, in which its applicability would be valid.

Among the criteria of scientific veracity related to the protocols, different types of validity, reliability and sensitivity are necessarily highlighted. There are three types of validity that can be applied to physical performance protocols. Regarding validity, we can subdivide it into: (1) logical validity, (2) predictive validity and (3) construct validity (CURREL; JEUKENDRUP, 2008; SANTOS, 2018; CHABEENE et al., 2018). The reliability, which is related to the objectivity of the measure, is subdivided into relative and absolute (CURREL; JEUKENDRUP, 2008). Figure 4 shows the relationships between the various aspects of scientific veridicality, which will be presented and exemplified in the following subsections, when possible using studies involving combat sport modalities.

Figura 4. Scientific veracity related to validation of physical tests



Source: Autor

In combat sports, Chaabene et al. (2018) published a study in which they carried out a critical review of methodological quality, related to studies that sought to validate specific tests for athletes in Olympic combat sports. A search was carried out over the main databases in which the following combat modalities were included: Amateur boxing, fencing, judo, karate, taekwondo and wrestling. The authors concluded that the majority of studies (64%) ignored and/or provided incomplete information about feasibility in addition to having major methodological limitations related to specific tests. Additionally, it was found that in 28% of the included studies, insufficient information or a complete lack of information was provided in the field of application of the test. With the results of this study, the authors presented some prerequisites related to specific tests, to be taken into consideration for future investigations, which are described below:

1. Significant sample (recommended above 30 participants);
2. Studies involving female athletes;
3. Take into account the different levels of athletes (example: elite and non-elite);
4. Details related to inclusion/exclusion criteria;
5. Details related to familiarization of athletes;

6. Information related to stability of test conditions;
7. Presentation of reliability levels (relative and absolute);

In addition, only one study verified the predictive validity of combat sports athletes. As an additional recommendation, the authors recommended that the researcher whose objective it is to validate a specific protocol should always take into account when carrying out specific protocols at least the three types of validity and criteria of reliability

4.3.1 Logic Validity

The logical validity of a test shows to what degree the measure obviously involves the performance being measured (MACDOUGALL; WENGER, 1991; THOMAS; NELSON, 2002; CURREL; JEUKENDRUP, 2008). Generally, this type of validity is obtained by judging the characteristics and/or content of a test, carried out by people with extensive experience in the modality and composed of people with recognized knowledge in the area in question (LIMA; KISS, 2003; SANTOS, 2018). For example, if a speed test measures the time it takes an athlete to cover a certain distance, then the test must be considered to have logical validity. In tests being developed for fighters, this kind of validity has not been explored much. This may be because sports professionals prefer more objective evidence about the validity of a measure.

In a recent study, Santos (2018) verified the logical validity of a test in combat sports, which was based on a questionnaire answered by 94 subjects who were divided into three groups: non-graduates (n=32) graduates (n=34), and postgraduates (n=28) in the field of physical education and sport. These subjects were asked about the feasibility of a specific test and the Frequency Speed of Kick Test (FSKT), which is widely used in combat sports, especially percussion. From the answers obtained, it was shown that the specific FSKT test is a test that can be taken into account to assess physical performance in taekwondo athletes. The responses were 45% of the individuals considered the test as “easy to understand”, regarding the applicability 48.9 % considered the test “very viable”, 75.5% believed that the main measure of the test is the anaerobic capacity and 59.6% believed that the test's multiple kick sets measure specifically the anaerobic capacity. Based on these results, it appears that the FSKT is a test that has logical validity as a measure of the anaerobic capacity of taekwondo practitioners and athletes.

4.3.2 Criterion Validity

The criterion validity shows to what degree the test measures are correlated with some gold standard (THOMAS; NELSON, 2002). The measures used are often validated according to some gold standard criteria, the main types being concurrent validity and predictive validity (THOMAS; NELSON, 2002; CURREL; JEUKENDRUP, 2008; MORROW JR et al., 2014; SANTOS, 2018). Both are based on the correlation coefficient (Pearson or Spearman), however, the main difference between them is the moment when the criterion is measured (MORROW JR et al., 2014). Concurrent validity involves the correlation between a test and a criterion, already validated and accepted, which are evaluated more or less at the same time, which is why it is called concurrent validity. An example of concurrent validity is the use of the distance covered in a given period to estimate the $VO2_{max}$ performed in an incremental treadmill test in a laboratory environment. (SOUZA et al., 2014).

Criterion validation is more frequent in combat sports. Recent studies can be cited involving the judo athletes (STERKOWICZ et al. 1999; KATRALI and GOUDAR, 2012; DETANICO et al. 2012; HESARI et al. 2013; MORALES et al. 2016), these studies used different criterion, such as the Wingate test, neuromuscular power for lower and upper limbs and incremental tests, handgrip strength to validate these aspects from measurements generated by tests performed with specific motor gestures from judo (see table 9 in the next topic).

In judo, some studies verified the predictive validity, relating performance in physical tests with performance in competition. Kons et al. (2017) investigated the relationship of performance in generic and specific tests with performance in official judo competition. Considering the generic tests, significant correlations were found between the match effective time and the parameters of jump height, power, speed and strength (r= 0.52-0.58) while for the specific tests, relationships were found between the *judogi* test with isometric bar and the effectiveness (r= 0.43) and the number of attacks in competition (r= 0.45).

4.3.3 Construct Validity

Construct validity refers to the degree in which the test measures a hypothetical construct, which is generally established by the relationship between the test results and some behavior (THOMAS; NELSON, 2002). Construct validity is performed in studies involving combat athletes, including judo athletes, mainly using the group difference methods (e.g. advanced and novice groups) (FRANCHINI et al., 2005, CHAABENE et al., 2018). This method is used to establish the construct validity in which the scores of a test applied in different

groups show the differences in an ability or in a trait are compared (SANTOS, 2018), mainly taking into account the discriminative point. We can mention, for example, winners *vs*. losers, beginners *vs*. advanced, medalists *vs*. non-medalists, men *vs.* women and adults *vs*. youth.

In order to verify the construct validity of tests that measure neuromuscular abilities, Detanico et al. (2016) tested variables related to shoulder rotation in the isokinetic dynamometer and vertical jump performance in judo athletes with state level. From the canonical discriminant function analysis, it was verified that the peak torque of internal rotation (function 1 = 0.37), the height of the heel (function 1 = -0.57) and the ratio of the peak torque of the internal and external rotation of the shoulder (function 1 = -0.52) were the variables that better discriminate novice and advanced athletes, thus demonstrating that neuromuscular parameters related to the strength of the shoulder rotators and the power of the lower limbs can differentiate athletes of different levels.

A study that deserves attention in relation to validity is that by Trava et al. (2016) in which, based on the evaluation of judo athletes in different specific tests, verified the discriminant validity (in order to verify the difference between the elite and sub-elite groups) and factorial validity (which determines whether the specific tests of the judo studied have a similar goal of measurement). The tests applied were: SJFT, Uchikomi Fitness Test (UFT), Santos Test and Ten-Station Judo Ability Test. The results showed that the SJFT and UFT are the best tests to discriminate groups of different levels and were all used in the study to measure important physical abilities for the specific performance of judo.

4.3.4 Reliability

Reliability is another important characteristic that a test must present (HOFFMAN, 2006). This statement seems to be true because in practice, the observed score often represents the sum of the true score and the error (WEIR, 2005). Sources of error include individual variability, instrument inaccuracy, fraud, and test conditions. When a test is reliable, it is consistent when repeated, keeping with the same conditions. Reliability is then the ability of a test to produce consistent and repeated results when applied under the same conditions, on different occasions or by different raters (MACDOUGALL; WENGER, 1991; LIMA; KISS, 2003; HOFFMAN, 2006; SANTOS, 2018). In other words, the smaller the dispersion of a set of data, measured under similar conditions, the greater the reliability of the test. For example, if a trained measure obtains similar values when measurements are taken in duplicates, the reliability is said to be good. If the test or the evaluator does not have good reliability, the

variation obtained in the measurement may only reflect the test variation and not the alterations caused by an intervention (SANTOS, 2018).

Absolute reliability is estimated by using any measure of dispersion, which indicates the total variability, in amplitude and value, of a measurement repeatedly performed. What you want to know is the amount of error expected in a test result. The practical importance of applying these measures can be briefly illustrated. We can cite as an example, a sports coach who follows the constant evolution of a specific athlete over a period of time. The coach chooses the performance measures/tests that will be used, and needs to know how much variation will occur in the measure (errors), because if this information is not known, it will be difficult to interpret if there are changes in performance and if they are true, or even the results of the variability of the measures. Therefore, when choosing the performance tests/measures that will be used in the athlete's routine, it is advised that the coach uses it several times, under similar conditions, to know how much variation the measure will have. Only in this way will the coach be able to know if those observed variations are the result of "real" changes in performance, or if the variations are within what is expected for that test when performed by a certain athlete. For reliability testing, measures of consistency (for example, intraclass correlation coefficient – ICC) and agreement (coefficient of variation and limits of agreement) between measurements are generally used (CURREL; JEUKENDRUP, 2008; SANTOS, 2018).

Table 3 shows consistency-type reliability values based on the ICC of specific tests validated for the judo modality. The SJFT stands out as one of the oldest and most used tests in the evaluation of judo athletes

Table 3. Studies that used the reliability analysis from the ICC to validate physical tests for judo.

Reference	Country	Sample	Protocol	ICC
Franchini et al. (1999)	Polish	5	*Special Judo Fitness Test*	Throws: 0.73 Index: 0.89
Franchini et al. (2011)	Brazil	28	*Judogi Grip Strength Test*	Isometric:0.98 Dynamic: 0.99
Almansba et al (2012)	Canada	7	*Uchikomi Fitness Test*	A+B sets: 0.88 Total reps: 0.97
Del Vecchio et al. (2014)	Brazil	16	*Hikidashi uchi-komi*	Test of 40s: 0.71 Test of 30s 0.87 Test of 20s: 0.93
Morales et al. (2016)	Spanish	11	*Randori Maximal Time to Exhaustion*	Time to exhaustion: 0.91

Fessi et al. (2018)	Tunisia	41	*Intermittent Judo Test*	Total reps: 0.98 Best reps: 0.99
Krstulovic et al. (2019)	Croatia	10	*Judo Physical Fitness Test.*	Index: 0.73 Repetitions: 0.85
Shiroma et al. (2019)	Brazil	12	*Judo-Specific Maximal Aerobic Power Test*	Velocity: 0.81 VO_{2max}: 0.86

4.3.5 Sensitivity

The sensitivity of a test is the ability to detect levels of changes in the variable that is intended to be evaluated. For decision-making during the training process related to the physical tests carried out over the training and competition season. The tests used provided information about the strengths and weaknesses of the athletes, the practitioner, the client and physical exercise programs (RHEA; PETERSON, 2012). This process will enable the multidisciplinary team (coaches, physical trainers, etc.) to develop more efficient and objective training programs.

To choose the tests that will be used by the multidisciplinary team of the modality in question, the crucial point is that the test measures an important characteristic for the modality (LOTURCO; NAKAMURA, 2016). Regardless of motives and objectives, the tests used at the beginning of a physical performance process aim primarily to identify the current physical state, strengths and weaknesses. Tests for these purposes are different from those used during training monitoring (RHEA; PETERSON, 2012). Table 4 summarizes the characteristics and definition of reliability, sensitivity and types of validity applied to physical tests.

Table 4. Synthesis of characteristics and definition of reliability, sensitivity and validity of physical tests.

Characteristic	Definition
Reliability	
Test – Retest	The consistency of measurements, or of an individual's performance over repeated testing sessions or the absence of measurement error (Safrit and Wood, 1989) In the literature several terms have been used interchangeably with reliability such as repeatability, reproducibility, consistency, agreement, concordance, and stability (Atkinson and Nevill, 1998)
Inter/ intra-evaluator	**Inter-rater:** the degree of agreement between assessments outcomes when undertaken by two or more testers (Baumgartner and Jackson, (1998) **Intra-rater:** the agreement among two or more trials undertaken by

	the same tester (Baumgartner and Jackson, 1998)
Sensibility	
Test sensitivity	The sport-specific test is able to detect small, but meaningful changes in performance (Currell and Jeukendrup, 2008)
Validity	
Logic	It refers to the logical measure of a test, that is, how much a specific test measures what it is intended to measure
Criterium	**Concorrent:** means that the performance protocol is correlated with a gold standard measure (Thomas et al., 2015) **Predictive:** Sport-specific outcome can predict sport performance (Thomas et al., 2015)
Construct	**Construct:** whether a sport-specific test can measure a quality or attribute that cannot be operationalized **Discriminative**: ability to assess performers of different ability (as rated by another measure) (Russell et al., 2010; Streiner et al., 2015) **Convergent:** relation of a sport-specific test with another measure of the same construct or associated measures (Barrow et al., 1989; Russell et al., 2010)

Adaptated from Chaabene et al. (2018)

Finally, based on the review presented, the importance of taking into account all the points addressed (types of validity, reliability and sensitivity) are highlighted, especially when you intend to carry out validation of specific protocols in combat sports, since these have high complexity due to their open actions, with varying intensities and direct disputes with opponents. It is recommended for future studies to present aspects related to the two types of reliability (relative and absolute), sensitivity and inter-connections of different types of validity, especially predictive validity, in which there is a scarcity of studies in combat sports.

4.4 Special Judo Fitness Test

One of the pioneer tests that have widely been used to assess the physical fitness of judokas is the SJFT proposed by Sterkowicz (1995) and described by Franchini et al. (1998). The test is divided into three periods: 15s, 30s and 30s with intervals of 10s between them. During each of the periods, the athlete throws two partners (distant six meters) as many times as possible, using the *Ipon-seoi-nage* technique. Immediately and one minute after the end of the test, the athlete's heart rate (HR) is checked. The number of throws is computed and together with the HR values an index is calculated. The better test performance is related to the lower index value (Equation 2).

$$Index\ \frac{HRfinal + HR1min}{total\ throws} \qquad Equation\ 2$$

Where:

HR final: Heart rate immediately after the end of the test.

HR after 1 min: Heart rate after 1 minute of the test.

Total Throws: number of throws completed on the test.

The test performance can be improved from an increase in the number of throws during the test periods, which shows improved speed, anaerobic capacity and efficiency in the execution. The lower heart rate at the end of the test represents better cardiovascular efficiency (aerobic capacity) for a specific effort and the lower heart rate one minute after the test indicates better recovery, which represents an improvement in aerobic capacity. The lower final index value demonstrated better test performance (DETANICO; SANTOS, 2012; STERKOWICZ-PRYBYZCIEN; FUKUDA; FRANCHINI, 2019). Table 5 presents a summary of studies that used the SJFT to assess performance in judo athletes.

Table 5. Synthesis of studies that used the SJFT to evaluate judo athletes.

Author/Year/Sex	Subjects (n)	Throws (total)	HR final (bpm)	HR after 1 min (bpm)	Index
Sterkowicz (1995)	20	E 27 ± 4 NE 24 ± 2	E 177 ± 9 NE 182 ± 6	E 130 ± 7 NE 136 ± 4	E 11.5 ± 2.5 NE 13.2 ± 1.3
Sterkowicz (1997)	11	24,5 ± 1,8	176 ± 14	130 ± 20	12.5 ± 1.1
Sterkowicz et al. (1999) M	15	28 ± 3	182 ± 6	150 ± 12	12.2 ± 1.4
Franchini et al. (2001)	6	24 ± 2	179 ± 11	157 ± 15	13.9 ± 1.0
Sterkowicz e Franchini (2001)	80	E 27 ± 2 NE 25 ± 2	E 180 ± 10 NE 185 ± 9	E 152 ± 18 NE 156 ± 15	E 12.1 ± 1.6 NE 13.6 ± 1.4
Iredale et al. (2003)	9	24 ± 2	187 ± 9	154 ± 15	14.1 ± 1.7
Khakhabrishvili et al. (2003)	14	E 25 ± 0	E 188 ± 0	E 162 ± 0	E 14.0 ± 0.2

		E 24 ± 0	E 177 ± 0	E 154 ± 0	E 13.8 ± 0.1
Franchini et al. (2005a) M	13	28 ± 2	179 ± 6	163 ± 10	12.2 ± 1.0
Franchini et al. (2005b) M	53	25 ± 2	186 ± 11	165 ± 13	14.1 ± 1.5
Sterkowicz et al. (2005)	9	29 ± 2	183 ± 5	156 ± 8	11.7 ± 0.9
Franchini et al. (2007) M	20	E 28 ± 3 NE 27 ± 2	E 178 ± 9 NE 175 ± 9	E157 ± 11 NE 151 ± 7	E 11.8 ± 1.1 NE 12.2 ± 1.2
Da Silva et al. (2008)	30	20 ± 2	184 ± 3	139 ± 4	15.9 ± 1.7
Janse de Jonge et al. (2009)	12	27 ± 2	174 ± 10	157 ± 11	12.2 ± 1.3
Wolska et al. (2009) F	11	24 ± 1	175 ± 7	129 ± 12	12.6 ± 0.6
Wolska et al. (2010) F	15	22 ± 1	181 ± 10	137 ± 10	14.4 ± 1.2
Boguszewska et al. (2010) M	8	25 ± 3	187 ± 20	129 ± 11	12.7 ± 1.9
Mendes e Ferreira, (2010)	8	22 ± 3	182 ± 8	155 ± 15	15.2 ± 2.9
Pereira et al. (2010) M	13	20 ± 1	190 ± 9	164 ± 9	17.7 ± 1.9
Franchini et al. (2011c) M	14	26 ± 2	196 ± 12	169 ± 9	14.3 ± 1.3
Miarka et al. (2011)	8	23 ± 1	187 ± 11	154 ± 11	14.4 ±1.3
Barreto et al. (2012)	23	21 ± 2	183 ± 12	161 ± 20	16.0 ± 2.6
Detanico et al. (2012b) M	18	27 ± 2	179 ± 10	155 ± 15	12.5 ± 1.3
Escobar-Molina et al. (2012)	10	26 ± 2	183 ± 7	160 ± 15	12.5 ± 1.3
Katralli e Goudar (2012) M	31	I 28 ± 1 A 28 ± 2	I 177 ± 9 A 181 ± 5	I 141 ± 21 A 142 ± 18	I 11.3 ± 1.4 A 11.4 ± 1.0
Wolska et al. (2013) F	14	22 ± 2	191 ± 4	153 ± 10	15.2 ± 1.5
Hesari et al. (2013) M	19	27 ± 2	177 ± 7	142 ± 10	11.7 ± 1.0

Sterkowicz-Pryzy et al. (2014) M	7	27 ± 1	181 ± 10	151 ± 13	11.9 ± 0.8
Abedemalek et al. (2015)	11	31 ± 2	182 ± 5	154 ± 2	10.8 ± 3.0
Bonato et al. (2015) M/F	9	26 ± 1	184 ± 7	155 ± 15	13.7 ± 0.7
Franchini et al. (2015) M	10	28 ± 1	197 ± 6	178 ± 9	13.6 ± 1.0
Sogabe et al. (2015a) M	18	26 ± 3	180 ± 7	151 ± 12	13.0 ± 2.0
Sogabe et al. (2015b) M	18	D 26 ± 2 N 26 ± 2	D 183 ± 7 N 183 ± 9	D 152 ± 12 N 150 ± 10	D 12.6 ± 1.1 N 12.9 ± 1.3
Sterkowicz-Pryzy et al. (2015)	17	28 ± 2	183 ± 8	136 ± 11	11.4 ± 1.1
Ohkawa et al. (2015)	24	27 ± 1	172 ± 8	146 ± 12	11.7 ± 1.2
Garbouj et al. (2016) F	17	23 ± 2	186 ± 8	160 ± 11	14.8 ± 2.1
Morals et al. (2016) M/F	11	29 ± 3	--------	-------	12.2 ± 0.9
Simenko e Karpljuk (2016) M	9	22 ± 1	191 ± 6	163 ± 12	16.1 ± 1.6
Astley et al. (2017) M	18	23 ± 1	185 ± 9	163 ± 13	14.6 ± 0.6
Lum (2017) M	11	23 ± 2	180 ± 10	134 ± 16	13.9 ± 1.7
Casals et al. (2017) M	22	27 ± 3	184 ± 9	155 ± 18	12.8 ± 1.5
Casals et al. (2017) F	29	26 ± 2	181 ± 14	157 ± 19	12.7 ± 1.2
Kons et al. (2017) M	22	28 ± 3	--------	--------	11.7 ± 1.5
Courel-Ibanez et al. (2018) M	22	E 24 ± 3 NE 24 ± 3	E 191 ± 8 NE 197 ± 9	E 150 ± 12 NE 152 ± 10	E 12.6 ± 1.1 NE 12.9 ± 1.3
Agostinho et al. (2018) M/F	45	27 ± 2	180 ± 11	156 ± 17	12.3 ± 1.3
Ceylan et al. (2018) M	7	27 ± 3	182 ± 10	165 ± 15	12.1 ± 2.5
Kons et al. (2018b) F	19	27 ± 2	177 ± 10	149 ± 15	12.5 ± 1.3
Kons et al. (2018c) M/F	20	28 ± 3	176 ± 12	143 ± 16	11.6 ± 1.5

M=masculino; F=feminino, I=iniciantes, A=avançados, D=dominante, N=Não dominante, S=Senior, J=Junior, E= Elite, NE= Não elite; HR= Hear Rate

Source: Adaptated from Sterkowicz-Prybyzcien; Fukuda; Franchini (2019)

The results in table 5 demonstrated that SJFT values have been reported by athletes of different ages. According to the classification table proposed by Franchini, Del Vecchio and Sterkowicz (2009) (Table 6), the male athletes in the studies are classified from regular to excellent in the number of throws, however, in the final HR and HR after 1 minute in the index, there is greater variability in the classification, ranging from very low to excellent. Six studies with results from good to excellent and four studies with results from regular to very low.

Table 6. Special Judo Fitness Test classificatory table for total number of throws, heart rate (after and 1-min after) and index.

Classification	Total of throws	HR_{final} (bpm)	HR_{1min} (bpm)	Index
Excelent	≥ 29	≤ 173	≤ 143	≤ 11.73
Good	27-28	174-184	144-161	11.74-13.03
Average	26	185-187	162-165	13.04-13.94
Poor	25	188-195	166-174	13.95-14.84
Very Poor	≤ 24	≥ 196	≥ 175	≥ 14,85

Adapted from the Franchini; Del Vecchio; Sterkowicz (2009). HR = Heart Rate

In order to stabilize criteria for the classification of young athletes, Agostinho et al. (2019) proposed classification tables for cadet and junior athletes (tables 7 and 8).

Table 7. Special Judo Fitness Test classificatory table for high-level male cadet judo athletes for total number of throws, heart rate (after and 1-min after) and index.

Classification	Total of throws	HR_{final} (bpm)	HR_{1min} (bpm)	Index
Excelent	≥ 30	≤ 163	≤ 132	≤ 11.15
Good	28–29	164–174	133–148	11.16–12.38
Average	25–27	175–195	149–175	12.39–14.32
Poor	23–24	196–200	176–184	14.33–15.92
Very Poor	≤ 22	≥ 201	≥ 185	≥ 15.93

Adapted from the Agostinho et al. (2018). HR = Heart Rate

Table 8. Special Judo Fitness Test classificatory table for high-level male junior judo athletes for total number of throws, heart rate (after and 1-min after) and index.

Classification	Total of throws	HR_{final} (bpm)	HR_{1min} (bpm)	Index
Excelent	≥ 31	≤ 162	≤ 127	≤10.40
Good	30	163–174	128–144	10.41–11.29
Average	26–29	175–188	145–168	11.30–13.52
Poor	23–25	189–198	169–184	13.53–14.18
Very Poor	≤ 22	≥ 199	≥ 185	≥ 14.19

Adapted from the Agostinho et al. (2018). HR = Heart Rate

In order to establish criteria for female athletes, Agostinho et al (2019) also established classification criteria for the cadet category (Table 9), whereas Sterkowicz-Przybycien and Fukuda (2014) proposed tables for the junior and senior categories (Tables 10 and 11, respectively).

Table 9. Special Judo Fitness Test classificatory table for high-level female cadet judo athletes for total number of throws, heart rate (after and 1-min after) and index.

Classification	Total of throws	HR_{final} (bpm)	HR_{1min} (bpm)	Index
Excelent	≥ 28	≤ 168	≤ 132	≤ 11.53
Good	27	169–176	133–148	11.54–12.63
Average	23–26	177–193	149–176	12.64–15.45
Poor	21–22	194–202	177–189	15.46–18.00
Very Poor	≤ 20	≥ 203	≥ 190	≥ 18.01

Adapted from the Agostinho et al. (2018). HR = Heart Rate

Table 10. Special Judo Fitness Test classificatory table for high-level female junior judo athletes for total number of throws, heart rate (after and 1-min after) and index.

Classification	Total of throws	HR_{final} (bpm)	HR_{1min} (bpm)	Index
Excelent	≥ 26	≤ 167	≤ 128	≤ 12.18
Good	25	168–175	129–139	12.19–13.71
Average	23–24	176–190	140–161	13.72–16.13
Poor	22	191–198	162–171	16.14–17.41
Very Poor	≤ 21	≥ 199	≥ 172	≥ 17.42

Adapted from the Sterkowicz-Przybycien; Fukuda (2014); HR = Heart Rate

Table 11. Special Judo Fitness Test classificatory table for high-level female senior judo athletes for total number of throws, heart rate (after and 1-min after) and index.

Classification	Total of throws	HR_{final} (bpm)	HR_{1min} (bpm)	Index
Excelent	≥ 30	≤ 160	≤ 129	≤ 10.21
Good	29	161–170	130–138	10.22–11.31
Average	26–28	171–189	139–158	11.32–13.48
Poor	24–25	190–199	159–167	13.49–14.52
Very Poor	≤ 23	≥ 200	≥ 168	≥ 14.53

Adapted from the Sterkowicz-Przybycien; Fukuda (2014); HR = Heart Rate

Recently, from a meta-analysis (STERKOWICZ-PRYBYZCIEN; FUKUDA; FRANCHINI, 2019), proposed a new classification for the SJFT, in honor of the creator and precursor of the test, Stanislaw Sterkowicz. This classification includes studies in the SJFT in the junior and senior age categories (Table 12).

Table 12. Special Judo Fitness Test classificatory table for high-level junior and senior judo athletes for total number of throws, heart rate (after and 1-min after) and index from the meta-analisys research.

Classification	Total of throws		HR_{final} (bpm)		HR_{1min} (bpm)		Index	
	Junior	Senior	Junior	Senior	Junior	Senior	Junior	Senior
Excelent	≥ 29	≥ 30	≤ 165	≤ 166	≤ 129	≤ 130	≤11.04	≤10.47
Good	27–28	28–29	166–173	167–173	130–140	131–141	11.05–12.23	11.48–11.68
Average	23–26	24–27	174–190	174–188	141–164	142–163	12.24–14.73	11.69–14.22
Poor	21–22	22–23	191–198	189–195	165–175	164–173	14.74–15.92	14.23–15.43
Very Poor	≤ 20	≤ 21	≥ 199	≥ 196	≥ 176	≥ 174	≥ 15.93	≥ 15.44

Adapted from the Sterkowicz-Prybyzcien, Fukuda e Franchini, 2019; HR = Heart Rate

In the search for better physiological information from the SJFT, Franchini et al. (2011) evaluated the contribution of the energy systems of 14 judo athletes who underwent SJFT. The results showed a higher energetic contribution to a lactic anaerobic metabolism (phosphagen system (ATP-PCr)) (40.4 ± 5.6%), followed by aerobic (oxidative system) (32.9 ± 3.3%) and then lactic anaerobic (glycolytic system) (26.7 ± 5.4%). From these results, it is possible to infer that the energy demand in the SJFT present high anaerobic demands, although in the latter, due to the longer time, there is a predominance of the aerobic resources (JULIO et al., 2017).

Considering that body composition can be a negative factor in the performance of judo athletes (ATHAYDE et al., 2017; KATRALLI; GOUDAR, 2012), Casals et al. (2015) verified the main body components based on anthropometric measures that predict performance on SJFT variables from different prediction equations. From this, the authors found three different equations to predict the SJFT index, the first is related to gender variation considering male athletes and body mass, in which it predicts 24%. The second model involved only the biceps skinfold, in which the predictive power was 30% and finally the third model involved bone mass, ectomorph profile and muscle mass, in which the junction of these components resulted in a predictive power of 40%.

In this direction, considering the influence of physiological parameters on the performance variables of the SJFT, Lopes-Silva et al. (2021) also performed different prediction equations to verify the physiological variables that best predict test performance in the SJFT, lower- and upper-body anaerobic power and capacity and graded maximal tests. The authors presented three equation models, in which they predicted different SJFT performance variables. The first model takes into account the VO_{2peak} in the incremental test and the Wingate test, both for upper limbs relativized by body mass, which predicted about 34% of the variation in the

total number of throws. The second model took into account the maximum heart rate in the incremental test of upper limbs and the heart rate of the lower limbs at the intensity corresponding to the onset blood lactate accumulation (OBLA) intensity, being able to predict about 54% of the final heart rate of the SJFT. Finally, the last model takes into account the relative VO_{2peak} for the body mass in the incremental test in the upper limbs, in which it predicted 15% of the index being considered low power..

In order to verify the contribution of neuromuscular parameters in the performance of the SJFT, Kons et al. (2020) performed predictive equation models for male and female judo athletes, aged between 11 and 16 years. From the results, two prediction models were found for each sex. Considering males, the first model demonstrates that performance on the standing long jump and medicine ball throw test predicts about 28% of the variation in the total number of throws and 20% of the test index. For females, the prediction based on these two tests was 24% for the number of throws and 27% for the test index.

Studies indicated that performance in the SJFT is influenced by several variables involving anthropometric, physiological and neuromuscular parameters, so it is essential that these parameters are monitored and controlled during the process of physical preparation of judo athletes, since they are associated with test performance which can be an excellent indicator of specific performance in judo and load control over a season training (AGOSTINHO et al., 2015).

In an attempt to investigate the influence of SJFT performance and performance in official judo competitions, Kons et al. (2017) verified a positive relationship between the second series of the SJFT and the effectiveness of attacks in competition ($r = 0.44$), demonstrating that a good performance in the test was related with a higher effectiveness parameter, which is related to the number of scores obtained by the number of throws during the matches in competition. Additionally Kons et al. (2018b) found that the anaerobic capacity inferredby the SJFT (total number of throws) is an important indicator of performance in matches that exceed 2 minutes, that is, athletes who presented good performance indicators in the number of throws in the test, they significant to have a longer effective time in competition which is linked to the timing of attacks, defenses and attempts to counter the opponent.

Additionally, studies have used other parameters to verify the construct validity, mainly relating to the main test variables, these being the total number of throws and the index. The table 13 presents some studies that sought to establish relationships between physical parameters (morphological, physiological or neuromuscular) with performance in the SJFT.

Table 13. Synthesis of studies that related morphological and physical performance variables to the total of throws and the SJFT index.

Studies	Samples	Variables SJFT	Variables correlated	Correlation Index
Sterkowicz et al. (1999)	15	Total throws / Index	Relative Wingate Work	0.71; -0.71
Katrali e Goudar, (2012)	31	Total throws	Body fat percentage	-0.69
Detanico et al. (2012)	18	Total throws	Jump height / Peak velocity in incremental test	0.74; 0.70
Hesari et al. (2013)	19	Total throws / Index	VO_{2max} / Wingate Peak power	0.78; -0.87; -0.74
Morales et al. (2016)	11	Total throws / Index	Peak power in Wingate relative work	0.77; - 0.78; -0.76

Finally, it is highlighted that the SJFT is one of the most used judo specific tests nowadays. Studies show that the test can be used to assess athletes of different ages, in addition to having good relationships with gold standard physical assessment methods. However, studies that take into account adaptations of this test to athletes with special populations are still scarce. Investigations must be carried out to better adapt the test to athletes with physical, visual and intellectual restrictions, since they already have a high-level of competitions for these athletes in the judo modality.

CHAPTER III

5. RESULTS

The results section will be divided into three parts, corresponding to the articles that were prepared to achieve to the established objectives. Table 14 shows the title of the articles that result from the thesis, the journal in which the article was published or submitted and the Qualis specification (CAPES in area 21) and impact factor.

Table 14. Articles that result from this thesis

Articles	Journal/Qualis/Impact Factor
1. The Effect of Vision Impairment On Competitive and Technical–Tactical Performance In Judo: Is The Present System Legitimate?	Adapted Physical Activity Quarterly (A2, 2.929)
2. Effect of vision impairment on match-related performance and technical variation in attacking moves in Paralympic judo	Journal of Sport Sciences (A1, 3.337)
3. Psychometric Suitability of Adaptations to the Special Judo Fitness Test for Athletes with Visual Impairment	Perceptual and Motor Skills (A2, 1.647)

5.1 Study 1.

The effect of vision impairment on competitive and technical–tactical performance in judo: is the present system legitimate?

Published in **Adapted Physical Activity Quarterly**, Volume 36: Issue 3, Pages: 388–398, 2019.

Abstract

In judo competition for visual impairment (VI), athletes of different classes compete against each other within the same category, where B1 athletes are totally blind, whereas B2 and B3 are partially sighted. To test for potential competition disparities due a single category of athletes, this study aimed to compare competitive and technical-tactical performance in VI judo athletes with different degrees of VI. We analyzed 340 judo matches of the 2012 and 2016 Paralympic Games. Scores, penalties, efficiency index and type of medals were examined, as well as technical variation and temporal structure. The main finding was that blind judo athletes presented lower scores ($p<.05$; ES=0.43-0.73), medals ($p<.05$) and efficiency ($p<.05$; ES=0.40-0.73), different patterns of play, and a shorter time to lose compared to partially sighted athletes ($p=.027$; ES=0.10-0.14); however, the penalties were similar between classes ($p>.05$; ES= 0.07-0.14). The odds ratio of a winning medal was 3.5-8 times lesser in blind athletes compared to partially sighted athletes ($p<.01$). In conclusion, judo blind athletes presented lower competitive and technical-tactical performance than athletes with some residual functional vision. These findings provide support for the development of new evidence-based criteria for judo classification based on vision impairment.

Keywords: Technical analysis; Paralympic sport; Combat sport; Visual impairment

Introduction

Judo for athletes with vision impairment (VI judo) is a Paralympic sport which follows the same rules as Olympic judo but with one main exception, as the match is initiated with athletes positioning their grips on the opponents' jacket (*judogi*) (International Paralympic Committee [IPC], 2018). This procedure is repeated every time that combat is interrupted (GUTIÉRREZ-SANTIAGO et al., 2011), thus athletes remain in physical contact throughout the entire match. This is unlike the Olympic judo, where athletes start a match without contact, needing to firstly engage in a fight for their grip before they can attempt to attack their opponent.

In most visual impairment sports, athletes compete against others with a similar degree of impairment within one of three sport classes (B1, B2 and B3 for athletes with the most to least severe level of impairment) (IPC, 2018). These classes are defined based on measures of the athletes' residual visual function, i.e. visual acuity (LogMAR) of B1 athletes are poorer than 2.6 and they can distinguish only light from dark or cannot perceive light. B2 athletes' present limited LogMAR of 1.5-2.6, visual field (radius) lesser than 5 degrees and severely limited visual acuity, whereas B3 athletes' present limited LogMAR of 1.0-1.4, visual field lesser than 20 degrees and visual acuity or visual field in both eyes. In VI judo, although athletes are allocated to one of these classes, they compete against athletes of all classes during the competition. Therefore, VI judo effectively holds only a single sport class for all athletes, ranging from athletes who are fully blind to partially sighted.

Previous studies have examined the relationship between vision impairment and performance in VI judo competitions, usually by the comparison of competitive results between judo athletes with different degrees of impairment. Mashkovskiy et al (2018) retrospectively analyzed 10 years of VI judo matches and found that the most severely impaired judo athletes (class B1) had a lower chance of winning against opponents with better visual function (class B2 or B3). Similarly, Krabben, et al (2018) reported that functionally blind athletes (class B1) won significantly fewer medals than partially sighted competitors (class B2 and B3) during the 2014 and 2015 VI Judo World Championships. These authors also examined the performance of judo athletes who competed against their opponents in both a sighted condition (with the opponent blindfolded) and in a blindfolded condition (with the opponent sighted). They observed that sighted judo athletes who fought against blindfolded opponents produced more scoring throws and obtained more points. These findings indicate that degree of vision

impairment impacts the results in VI judo competitions. Additionally, a lower performance in blind individuals may be associated to the higher delay in fundamental motor skills compared to non-blind individuals (WAGNER et al., 2013; HAEGELE; BRIAN; GOODWAY, 2015).

Although there is evidence that the degree of vision impairment impacts the outcome of VI judo competitions (KRABBEN et al., 2018; MASHKOVSKIY et al., 2018), it is less clear which aspects of performance are predominantly impacted by vision impairment. These studies have focused on the outcome of VI judo competitions (frequency of medals and scores) rather than the course of events during those competitions. A more detailed analysis of relationship between vision impairment and technical-tactical parameters of judo performance, e.g. scores, penalties, technical variation (throwing and groundwork techniques) and temporal structure (time motion analysis during matches in competition) will improve the understanding of the VI judo athletes profile (ADAM; SMARUJ; TYSZKOWSKI, 2011; GUTIÉRREZ-SANTIAGO et al., 2011). This knowledge would allow better structuring of VI judo competitions so that athletes should compete against others with more similar activity limitations. Additionally, it would help to determine whether or not the current competitive system used in VI judo matches is fair.

Therefore, this study aimed to analyze the technical-tactical and competitive performance in VI judo between athletes with different degrees of vision impairment. To achieve this, we compared the scores, penalties, technical efficiency, technical variation and time motion between athletes allocated to different sport classes who competed in the 2012 and 2016 Paralympic Games. In addition, we identified the likelihood of athletes with more severe vision impairment winning medals at the Paralympic Games. We hypothesized that functionally blind athletes (B1 class) would obtain a lower percentage of scores, medals, efficiency and technical-tactical parameters when compared to athletes with some residual functional vision (B2 or B3 classes), resulting in a lower likelihood of winning medals for more severely impaired athletes.

Methods

Procedures

Data for this study were extracted from the Official Result Books of the Paralympic Games (PG) in London, 2012 and Rio de Janeiro, 2016, organized by the Paralympic Committee of each country. The Official Results Books were documented by a judo expert referee of the

International Judo Federation (IJF). Varied information were extracted from the Result Books for further analysis, such as number and type of scores, penalties, technical variation, time motion analysis during the matches, etc. Afterward, a judo expert (coach of judo VI, more than 15 years of judo experience and black belt) tabulated the data and performed the statistical analysis.

Participants

We analyzed all matches from seven male and six female weight categories of PG London 2012 and Rio 2016. Considering the rules of IJF competition, there are two semifinals where the winners met in the final for the gold and silver and, two semi-final winners met for bronze and 4th place. Participants were counted every time they fought, totaling 340 matches. The total number of athletes in both PG was 244, which included 51 athletes classified as B1 (39 men and 12 women), 116 B2 athletes (66 men and 50 women) and 91 B3 athletes (60 men and 31 women). It was computed that 16.46% of men and 18.28% of women athletes participated in both PG. Age ranged from 20 to 38 years.

In PG London 2012 the five continents took part. In Africa only Algeria with three athletes participated. Europe presented higher number of participants: Azerbaijan (n= 7), Belarus (n= 2), Bulgaria (n= 1), Spain (n= 6), Finland (n= 2), France (n= 7), Great Britain (n= 5), Germany (n= 5), Hungary (n= 2), Russia (n= 10), Sweden (n= 1), Turkey (n= 6) and Ukraine (n= 7) participated. In Asia, China (n= 8 athletes), Iran (n= 6), Japan (n= 8), Republic of Korea (n= 3), Mongolia (n= 2), Thailand (n= 1), Chinese Taipei (n= 1) and Uzbekistan (n= 1) participated. Finally, in Pan-America participated Argentina (n= 3 athletes), Brazil (n= 9), Canada (n= 3 athletes), Colombia (n= 1), Cuba (n= 5), Mexico (n= 3), United States (n= 6) and Venezuela (n= 4).

In PG Rio de Janeiro 2016 the five continents also participated. In Africa, only Algeria (n= 3) took part. In Europe, Azerbaijan (n= 7 athletes), Belarus (n= 2), Croatia (n= 1), Spain (n= 4), France (n= 2), Great Britain (n= 5), Georgia (n= 1), Germany (n= 5), Greece (n= 1), Hungary (n= 2), Lithuania (n= 1), Portugal (n= 1), Romania (n= 1), Sweden (n= 1), Turkey (n= 4) and Ukraine (n= 9) participated. In Asia, China (n= 5 athletes), Iran (n= 3), Iraq (n= 1), Japan (n= 9), Kazakhstan (n= 2), Republic of Korea (n= 6), Mongolia (n= 2), Thailand (n= 1), Chinese Taipei (n= 2) and Uzbekistan (n= 11) participated. Finally, in Pan-America participated Argentina (n= 5 athletes), Brazil (n= 12), Canada (n= 2), Cuba (n= 5), Mexico (n= 2), United States (n= 5), Puerto Rico (n= 1), Uruguay (n= 1) and Venezuela (n= 4).

Description of variables

Total number of scores and penalties obtained during the matches were collected (considering each athlete). A penalty (*shido*) is awarded for minor infringements such as stepping out of the mat area or stalling the fight. Scores are awarded for successfully executed techniques. Scores were subdivided into *ippon* (highest score, which immediately ends the match), *wazari* (medium score) and *yuko* (small score), from which an efficiency index was calculated. The efficiency index represents the sum of the points obtained during the competition, considering the evaluation of the referees divided by the total number of matches (ADAM et al., 2011), as per Equation 1. Additionally, we recorded the distribution of medals according to sex and sport classes.

$$\text{Efficiency} = \frac{(\text{number of } \textit{ippon} \times 10) + (\text{number of } \textit{wazari} \times 7) + (\text{number of } \textit{yuko} \times 5)}{\text{Total number of matches}}$$

Equation 1

The technique or penalty that decided the outcome of each contest was collected from the Official Results Books. Judo techniques were divided into throwing techniques (*Nage-waza*) and groundwork techniques (*Katame-waza*), then further classified according to the official technical classification (Kodokan Institute, 2018). Throwing techniques were subdivided into hand techniques (*Te-waza*), foot techniques (*Ashi-waza*), hip techniques (*Koshi-waza*) and sacrifice techniques (*Sutemi-waza*). Hand, foot and hip techniques refer to the main body part used to tip the opponent over. Sacrifice techniques are throws where the attacking judoka drops him/herself on his back first (i.e., 'sacrifices' their self) in order to execute the throw (Daigo, 2005). In addition, groundwork techniques were subdivided into pinning techniques (*Osaekomi-waza*), joint locking techniques (*Kansetsu-waza*) and choking techniques (*Shime-waza*). Additionally, the total duration of each match (in seconds) was collected and recorded as the "time to win" for the winning athlete and as the "time to lose" for the losing athlete. No ethical committee was consulted prior to conducting this study as data were obtained in secondary form and were not generated by experimentation (MORLEY ; THOMAS, 2005).

Statistical analysis

Data from London 2012 and Rio 2016 PG were combined to analyze competitive and technical-tactical performance. The data normality was assessed by Kolmogorov-Smirnov test and all variables showed normal distribution. One-way ANOVAs with Bonferroni post-hoc tests were used to compare the scores and time-motion variables between athletes with different degrees of vision impairment (sport classes B1, B2 and B3). Chi-square tests were used to test the association between vision impairment and the distribution of judo techniques, and between vision impairment and medal distribution. Significant associations were followed by post-hoc analysis of the adjusted residuals with Bonferroni corrections (MACDONALD;GARDNER, 2000). Logistic regression was used to determine the odds ratio of the sport class (B1, B2 and B3) to be a medalist (general and per sex) and to win gold, silver and bronze medals in the PG. The significance level was set at .05, and all analyses were conducted using SPSS version 17.0. The Effect Size (ES) was also calculated from partial eta squared obtained by Anova one-way, and Hopkins' criterion was used classify magnitude of effects, as follow: 0.0–0.2, trivial; 0.21–0.6, small; 0.61–1.2, moderate; 1.21–2.0, large; 2.1–4.0, very large (HOPKINS, 2002).

Results

Table 1 shows the frequency per match of scores, penalties and efficiency of male and female athletes according to the sport class during the PG (London 2012 and Rio 2016). Significant differences in ippon scores were found between athletes with different degrees of vision for males ($F_{(2,39)} = 9.60$, $p < .0001$, ES = 0.70, moderate) and females ($F_{(2,33)} = 9.19$, $p = .001$, ES = 0.73, moderate). Post-hoc values showed higher values for B2 ($p = .001$) and B3 ($p = .006$) compared to B1 athletes in the female group, and higher values for B2 compared to B3 ($p = .024$) and B1 ($p < .001$) in the male group.

Wazari was significantly different between the classes in male athletes ($F(2,39) = 3.82$, $p = .030$, ES = 0.43, small), being higher in B2 compared to B1 ($p = .023$), while yuko was significantly different between the classes only for the female group ($F_{(2,33)} = 5.02$, $p = .012$, ES = 0.54, small), being higher in B3 compared to B1 ($p = .010$). Efficiency differed significantly in the male ($F_{(2,39)} = 3.42$, $p = .045$, ES = 0.40, small) and female ($F(2,33) = 8.95$, $p = .001$, ES = 0.73, moderate) groups, with higher values observed for B2 ($p = .08$) and B3 ($p = .01$) compared to B1 in both groups, and B3 was higher than B1 in the female group. The number of penalties did not differ between athletes with different degrees of vision in male (F

$_{(2,39)}$ = 0.28, p = .75, ES = 0.14, trivial) or female ($F_{(2,33)}$ = 0.92, p = .40, ES = 0.07, trivial) groups.

Table 1**.** Frequency per match of scores, penalties (*shido*) and efficiency of male and female judo athletes according to the sport classes during the PG.

	Male (score/match)			**Female** (score/match)		
	B1	B2	B3	B1	B2	B3
Ippon	0.20 ± 0.16*	0.43 ± 0.12	0.29 ± 0.12*	0.07 ± 0.14*#	0.37 ± 0.13	0.34 ± 0.25
Wazari	0.05 ± 0.08*	0.17 ± 0.11	0.12 ± 0.13	0.06 ± 0.12	0.10 ± 0.09	0.08 ± 0.11
Yuko	0.21 ± 0.20	0.30 ± 0.21	0.33 ± 0.28	0.10 ± 0.16#	0.32 ± 0.20	0.45 ± 0.39
Shido	0.62 ± 0.56	0.68 ± 0.32	0.75 ± 0.36	0.32 ± 0.42	0.49 ± 0.33	0.50 ± 0.29
Efficiency (%)	3.5 ± 2.4*	6.2 ± 2.8	5.6 ± 3.2	2.0 ± 2.4*#	5.8 ± 2.0	6.7 ± 3.9

Ippon: highest score, which immediately ends the match, wazari: medium score, yuko: small score, shido: minor penalty, *Different from B2, #Different from B3

According to the results, 71.8% of all matches were won by standing techniques and 28.2% were won by groundwork techniques. This distribution was very similar across sport classes (Figure 1A). A chi-square test confirmed that this distribution was not associated with the degree of vision impairment (χ^2 = .007, p = .97). Figure 1B shows the distribution of the different types of standing techniques (leg, hip, arm and sacrifice throws) for athletes with different degrees of vision impairment. As seen in Figure 1B, blind athletes predominately showed sacrifice techniques throws compared to other classes. Chi-square test showed that the distribution of standing winning techniques was significantly associated with the degree of vision impairment (χ^2 = 13.73, p = .03).

Blind (B1) athletes predominantly used sacrifice throws, athletes with more residual vision (B2) mostly won using hand throws, and athletes with the most residual vision (B3) predominantly applied leg throws. Post-hoc analysis revealed that the only significant difference was that B2 athletes won significantly more matches using hand techniques (p < .001). No significant associations were observed between the type of technique and the degree of vision impairment for groundwork techniques (χ^2 = 4.51, p = .34; Figure 1C).

Figure 1. (A) Distribution of standing and groundwork techniques in different sport classes; (B) Leg, hip, hand and sacrifice throws techniques in different sport classes; (C) Pins, armlocks and chokes techniques in different sport classes.

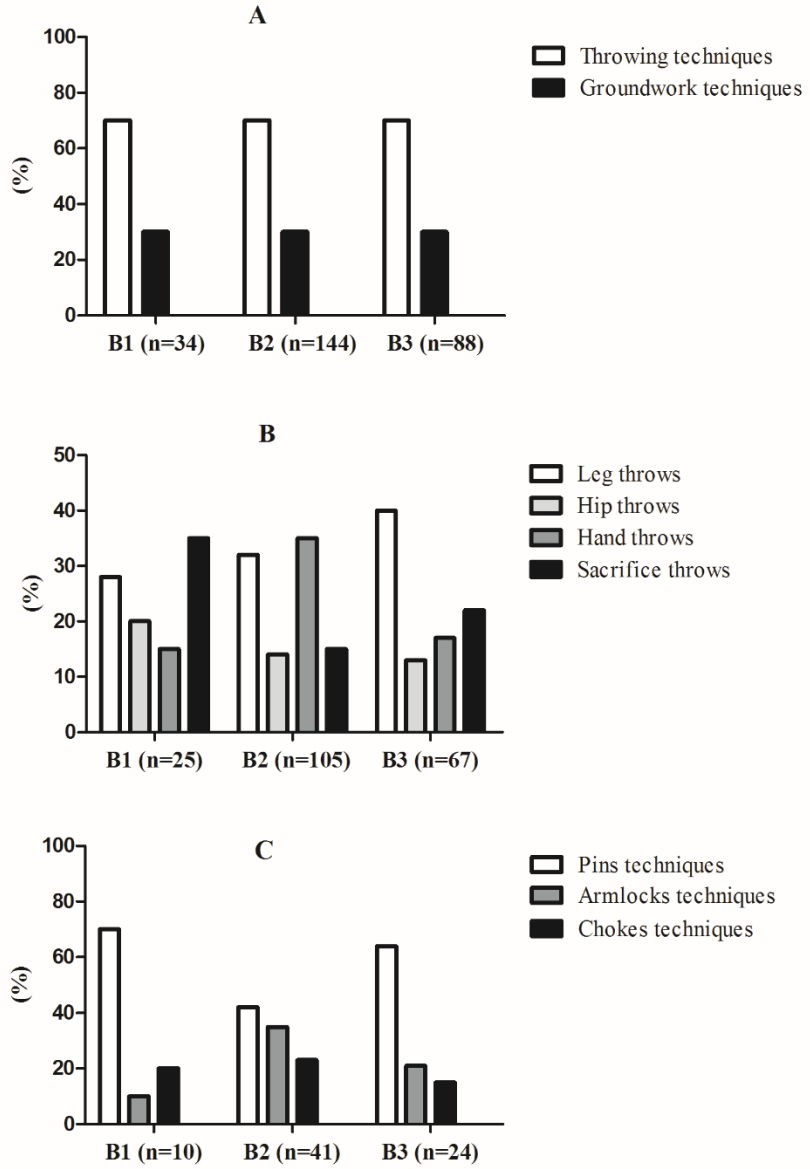


Figure 2 presents the time to win and time to lose during the PG according to sport class. A significant difference was found only for time to lose ($F_{(2,337)} = 3.63$, $p = .027$, ES = 0.14; Figure 2B). The post-hoc test revealed significantly higher values for B3 compared to B1 athletes ($p = .028$), but no significant difference between B2 and B3 groups ($p = .10$) or between B2 and B1 groups ($p = .90$). There was no significant difference in time to win between groups with different degrees of vision impairment ($F_{(2,337)} = 1.73$, $p = .19$, ES = 0.10; Figure 2A).

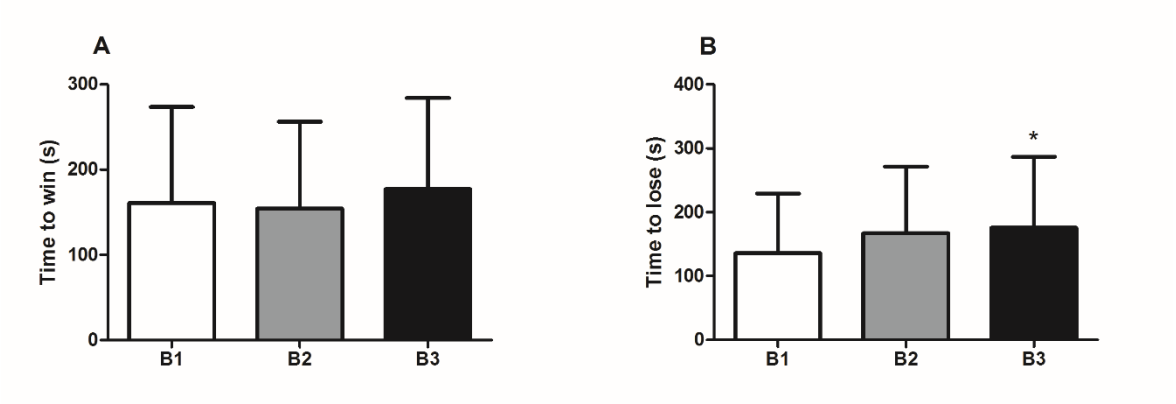


Table 2 shows the absolute and relative frequencies of medalists and non-medalists athletes according to the sport classes. We verified a significant association between the degree of vision impairment and medal distribution in both male ($\chi^2 = 7.50$, $p = .023$) and female ($\chi^2 = 7.05$, $p = .029$) athletes, i.e. the frequency of winning medals depends on degree of visual impairment. Male B2 and B3 athletes obtained a higher medal percentage (47.5% and 35.8%, respectively) than B1 athletes (20.5%, $p < .01$). Similarly, female B2 and B3 athletes showed a higher medal percentage (56.3% and 39.6%, respectively) compared to B1 athletes (4.5%, $p < .01$). The number of medals did not differ between B2 and B3 for either sex ($p > .05$).

Table 2. Association between medalists/non-medalists and sport classes (B1, B2 and B3) in the PG (absolute and relative frequencies).

		Male		Female	
		Medalists	Non-medalists	Medalists	Non-medalists
B1	N	8	31	2	10
	%	20.5	79.5	4.2	21.7
B2	N	29	32	27	24
	%	47.5	52.5	56.3	52.2
B3	N	19	34	19	12
	%	35.8	64.2	39.6	26.1

Table 3 presents the odds ratio for athletes of different sport classes to be gold, silver or bronze medalists in the PG. The results showed that the odds ratio of male B2 athletes who won medals was 3.5-times higher than B1 athletes (reference group), while in the female team, the odds ratio of B2 and B3 athletes to win a medal was 5-8-times higher than B1 athletes. Across

all athletes (male and female), the odds ratio of B2 and B3 athletes winning a medal was close to 4-times higher than B1 athletes. Analyzing the type of medals, the odds ratio of winning a gold medal was 7-times higher for B2 compared to B1 athletes (considering both sexes), whereas the odds ratio of winning a bronze medal was 4-times higher for B2 and 6-times higher for B3 compared to B1 athletes.

Table 3. Odds ratio (OR) and 95% confidence intervals (CI) of the sport class (B1, B2 and B3) to be a medalist (general and per sex) and to win gold, silver and bronze medals in the PG.

	B1 – Ref.	B2 – OR (CI 95%)	p	B3 – OR (CI 95%)	p
Medalists					
Male	1	3.5 (1.39 – 8.86)	.008*	2.1 (0.83 – 5.6)	.11
Female	1	5.6 (1.11 – 28.2)	.036*	7.9 (1.47 – 42.5)	.016*
Both	1	4.4 (2.04 – 9.71)	<.001*	3.6 (1.62 – 8.19)	.002*
Type of medals					
Gold	1	7.2 (1.6 – 33.0)	.010*	3.2 (0.64 – 16.2)	.15
Silver	1	3.0 (0.95 – 9.8)	.059	2.9 (0.37 – 5.31)	.61
Bronze	1	4.4 (1.42 – 13.7)	.010*	6.0 (1.95 – 18.8)	.002*

OR = odds ratio, CI = Confidence interval, Ref. = Reference *Different from Ref.

Discussion

The objective of the current study was to compare the technical-tactical and competitive performance of VI judo athletes with different degrees of vision impairment during PG of London 2012 and Rio 2016. In agreement with our hypotheses, the main findings of this study were: (a) functionally blind athletes obtained a lower percentage of scores, medals and efficiency compared to those with some residual functional vision; (b) the number of penalties was similar between judo athletes with different degrees of vision impairment; (c) degree of vision impairment was significantly associated with the distribution of different types of standing techniques used to decide a match, but not with the distribution of different types of groundwork techniques or the overall distribution of standing and groundwork techniques; (d) when they lost, athletes with the most residual vision lasted longer in the match than functionally blind athletes; (e) the odds ratio to win medals was lower for functionally blind athletes compared to partially sighted athletes, particularly the odds ratio to win a gold medal (up to seven-times less).

In agreement with earlier analyses of competitive results in VI judo (KRABBEN et al., 2018; MASHKOVSKY et al., 2018), we found that functionally blind athletes obtained less competitive success than their partially sighted opponents. A judo match can be decided either on points (for scoring techniques) or penalties (for infringements of the rules). In this study, we identified that differences in competitive success can be attributed to the most severely impaired athletes scoring less in the competition rather than obtaining more penalties. This might be partially due to the specific refereeing instructions to "have feeling for the B1 judoka", for instance, by being more reluctant to penalize blind athletes for stepping outside of the mat area. However, whether or not referees are more lenient towards blind athletes in penalizing minor infringements, the main disadvantage for athletes without functional vision seems to be more fundamental, particularly their ability to successfully apply skilled actions such as throws and groundwork techniques.

We also suggest that functionally blind athletes do not only score less, but seem to use different groups of throwing techniques. Functionally blind (B1) athletes used a higher percentage of sacrifice techniques, while athletes with some residual functional vision (B2 and B3) more frequently scored using other hand and leg throws, respectively. It is conceivable that visual demands differ between different types of techniques, and athletes may adapt their style of play to better fit their visual capabilities. For example, sacrifice throws require the attacking judoka to firstly drop themselves on their back before throwing the opponent over (DAIGO, 2005). These techniques can be executed from a close distance, with less reliance on visual information than for hand or foot techniques, which require precise turning or detection of the position of the opponent's feet. However, whether different patterns of play relate to different levels of competitive success remains unclear. Further analyses are required to better understand different patterns of play in judo, and to relate these to both vision impairment and competitive success.

The time to win during matches did not differ between athletes with different degrees of vision impairment; however, athletes with the most residual visual function (B3) lasted significantly longer in matches that they eventually lost when compared to the most severely impaired athletes (B1) i.e. in general, B3 athletes fought for longer before losing matches compared to the B1. Cardenes, et al (2018) considered combat time as an indicator of the level of asymmetry between athletes (i.e. degree of dissimilarity between the fighting skills), as combats between closely matched opponents are likely to last longer, whereas in cases of great asymmetry between athletes, the winner is more likely to finish the match quickly. In line with

this reasoning, losing athletes with the least visual function appeared to have greater asymmetry with their opponent when compared to athletes with the most visual function.

We concluded that judo blind athletes presented lower competitive and technical-tactical performance than athletes with some residual functional vision. The findings of our study ratify the need to change the manner in which VI judo athletes are currently competing to minimize the impact of impairment on the outcome of competition. The current format violates the aim of the Paralympic classification (KRABBEN et al., 2018), which is to minimize the impact of impairment on the outcome of competition (TWEEDY; VANLANDEWIJCK, 2011). A better understanding of the relationship between vision impairment and specific aspects of judo performance can be provided by our study, which is a critical step in the development of new evidence-based criteria for judo classification (TWEEDY; VANLANDEWIJCK, 2011; MANN; RAVENSBERGEN, 2018).

Funding

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References

The references of the paper are at “references section” page 103.

5.2 Study 2

Effect of vision impairment on match-related performance and technical variation in attacking moves in Paralympic judo

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Abstract

In Paralympic judo for athletes with vision impairment (VI judo) all eligible athletes (i.e. B1, B2 and B3 classes) compete against each other in the same competition. Evidence suggests that athletes with more impairment may be disadvantaged, but that more sensitive measures of performance are necessary to understand the impact of impairment on performance. The aim of this study was to investigate the relationship between Para sport class and technical variation, time-motion variables, and performance in Paralympic judo. All 175 judo matches from the Rio 2016 Paralympic Games were analyzed across 129 competitors (82 male and 47 female). The main results indicated that athletes who demonstrated less technical variation also experienced less competitive success, with the functionally blind athletes (class B1) demonstrating less technical variation than partially sighted (class B2 and B3) athletes ($p<0.05$). There was no difference in the time-motion variables between sport classes ($p>0.05$). We conclude that measures of technical variation are sensitive to differences in impairment and are suitable for studies that investigate the impairment-performance relationship in VI judo. Results further confirm that some athletes with impairment are disadvantaged under the current rules of VI judo.

Keywords: Combat Sports, Paralympic Judo, Time-Motion, Variability, Classification.

Introduction

Movement variability has traditionally been considered a source of noise which needs to be reduced, but is more recently recognized as a key element of expertise in sports (SEIFERT, BUTTON; DAVIDS, 2012; DAVIDS et al., 2015; BARTLETT; WHEAT; ROBINS, 2007). Successful sports performance requires an optimal mix between stability and flexibility, which enables the performer to functionally adapt to dynamic (sport) environments (VAN EMMERIK;VAN WEGEN, 2000; FAJEN; RILEY; TURVEY, 2009) and allows creative motor actions to emerge (ORTH et al., 2017). This is especially clear in interactive sports, where athletes need to co-adapt their own behaviors to that of their opponent (PINDER et al., 2012; HRISTOVSKI et al., 2012). To outperform a direct opponent (e.g., pass a defender in soccer, or strike an opponent in boxing), athletes may need to operate in metastable performance regions, where multiple competing modes of action co-exist and small perturbations can shift the dynamics of the contest either way (DUARTE et al., 2012; HRISTOVSKI et al., 2006; KRABBEN; ORTH; VAN DER KAMP, 2019b; KIMMEL; ROGER, 2018). The key implication for athletes in interactive sports is that a wider repertoire of movements will provide more options during a match and likely be associated with greater competitive success (KRABBEN et al., 2019b).

Judo is a highly dynamic and interactive sport which requires a variety of complex technical and tactical skills such as gripping, unbalancing, and throwing an opponent (BRANCO et al., 2013; MIARKA et al., 2016). The behaviors of both athletes in a judo match are directly interdependent: action opportunities for one judo athlete continuously emerge and decay during a match depending on the behaviors of the other combatant (KRABBEN et al., 2019b; GUTIÉRREZ-SANTIAGO et al., 2011; MIARKA et al., 2012). Judo athletes thus need to constantly anticipate and (re)act to their opponent (PIRAS; PIERANTOZZI ; SQUATRITO, 2014) to successfully execute offensive and defensive actions (COUREL et al., 2014). Judo athletes are encouraged to develop a range of throwing techniques to increase the unpredictability of their actions and enhance their chance of winning (CALMET; AMAIDI, 2004; MIARKA, et al., 2015). Technical variation might even distinguish good from excellent elite-level judokas. Judokas who repeatedly won medals at the World or Olympic level have been found to be able to apply a greater number of different throwing techniques in matches compared to athletes who also medaled at the elite level, but who were less consistent in their performance over time (FRANCHINI et al., 2008).

Despite the assumed benefit of technical variation in Olympic judo athletes, it remains unclear whether the relationship remains in Paralympic judo for athletes with vision impairment (VI judo), and therefore, whether technical variation is a marker of success in the sport. Although there are technical and tactical similarities between VI Judo and its Olympic counterpart, there is one key adaptation to the sport that alters the nature of competition. In VI judo, athletes must start the match with a two-handed grip on the jacket of the opponent already in place to decrease the visual demands of the sport (KONS et al., 2018; GUTIÉRREZ-SANTIAGO et al., 2011). This is in contrast to able-sighted judo, where athletes start the bout a few meters apart, after which they first must fight to engage and grip their opponent before they can attempt to throw him/her (GUTIÉRREZ- SANTIAGO et al., 2011). The adaptation in VI judo constrains the initial position of the athletes and might alter the type of throwing techniques they are capable of using. Accordingly, technical variation might not be a marker of success in the sport.

In VI judo, athletes with different degrees of vision impairment (ranging from partially sighted to fully blind) are allocated to one of three different sport classes commonly used across almost all VI sports (B1, B2 and B3 for athletes with the most to the least severe degree of impairment, see Table 1). However, during competition all judokas compete against each other in the same competitive class. This is unlike most other VI sports, where competition is divided into different sport classes to ensure athletes compete against others with a similar degree of activity limitation (TWEEDY ; VANLANDEWIJCK, 2011; MANN ; RAVENSBERGEN, 2018). The assumption has been that the adaptations made to the sport ensure that the most severely impaired athletes who are functionally blind (in particular the B1 athletes) must be able to compete fairly even against those with the least impairment (i.e., B3 athletes) when competing together in the same competition.

Previous studies have already raised doubt that functionally blind athletes are able to compete equitably in elite level VI judo competitions against those with some residual visual function (KRABBEN; VAN DER KAMP; MANN, 2018; MASHKOVSKIY; MAGOMEDOVA; ACHKASOV, 2019; KONS et al., 2019; KRABBEN, et al., 2020). For instance, Kons et al. (2019) reported that the odds ratio for winning a gold medal at the 2012 and 2016 Paralympic Games was up to seven-times lower for functionally blind athletes (class B1) compared to partially sighted athletes (class B2 and B3). However, it is less clear which aspects of judo performance are mostly limited in athletes with full loss of vision. Kons et al. (2019) explored some technical-tactical and time-motion parameters that might explain the

differences in performance through an analysis of the final throwing technique used that resulted in wins at the 2012 and 2016 Paralympic Games. The authors verified that both time-motion variables (e.g., time to lose) and the winning technique were different between functionally blind (B1) and partially sighted (B2 and B3) athletes. This is useful from the perspective of evidence-based classification research, because it provides additional measures of performance that could be used to better understand the relationship between vision impairment and performance in VI judo (i.e., to address Step 3b in Tweedy et al.'s (2016) five-step model for evidence-based classification research to develop sport-specific measures of determinants of performance). Yet although the aforementioned study analyzed the winning technique, the degree of variability of techniques that athletes use in VI judo remains unclear. Considering that judo performance in able-sighted judo is related to a judoka's degree of technical variation (CALMET; AMAIDI, 2004; FRANCHINI et al., 2008; MIARKA et al., 2015), technical variation might also be a relevant determinant of performance in Paralympic judo. If so, it could be used as an additional measure of performance when establishing the impairment-performance relationship to establish new evidence-based sport classes in VI judo.

The aim of this study was to investigate the relationship between Para sport class and technical variation, time-motion variables, and performance in Paralympic judo. We analyzed the performance of all Paralympic judo athletes who participated in the Rio 2016 Paralympic Games (PG) to determine differences in technical variation, match-related performance, and competitive success across the different sport classes. We hypothesized that functionally blind (B1) athletes would show lower levels of technical variation and competitive success (e.g. win ratio) than partially sighted (B2 and B3) athletes. In particular, we expected that judokas who showed higher levels of technical variation would be more successful during competition. The results were expected to be useful in uncovering potentially new measures of performance for establishing the impairment-performance relationship in VI judo.

Table 1. Classification criteria for VI athletes according to International Blind Sports Federation (IBSA) regulation.

Class	Visual acuity (LogMAR)	Visual field (radius)	Description
B3	1.0 to 1.4	Less than 20 degrees	Limited visual acuity and/or visual field in both eyes
B2	1.5 to 2.6	Less than 5 degrees	Severely limited visual acuity and/or visual field in both eyes.
B1	Poorer than 2.6	Cannot be B1 with only loss of visual field	An athlete can distinguish only light from dark, or is not able to perceive light.

Method

Data sample

Data for this study were extracted from the Official Result Books of the Rio de Janeiro 2016 PG, documented by a judo expert referee from the International Judo Federation (IJF). The results book includes detailed match information including the temporal structure and technical aspects of each match (e.g., type of judo techniques applied). The lead author, who is a judo black belt as well as a VI judo coach, tabulated the data and performed the statistical analyses.

We analyzed all 175 matches from seven male weight categories (111 matches) and six female weight categories (64 matches)[1]. A total of 129 athletes took part (82 men and 47 women), representing 36 different national federations. Twenty-four athletes were classified as B1, 58 as B2 and 47 as B3. The B1 athletes competed on average in 2.3 ± 1.2 matches (mean ± SD), B2 athletes competed in 2.9 ± 0.8 matches, and B3 athletes in 2.7 ± 2.9 matches. The structure of Paralympic judo takes the form of a 'knock-out' competition, similar to Olympic judo, where judokas who win continue to the next round, and those defeated are 'knocked out' of the competition. At the Rio Paralympic Games, judokas each competed in a minimum of one and a maximum of four matches. No ethical committee was consulted prior to conducting this study because data were obtained in secondary form from a publicly available source and were not generated by experimentation (MORLEY ; THOMAS, 2005).

Description of variables

In judo, scores are awarded for successfully executed techniques, subdivided into *ippon* (highest score, which immediately ends the match), *waza-ari* (medium score), and *yuko* (small score) according to the rules applied during the PG Rio 2016. For each score in each match, we extracted who made the score, what time in the match the score was made, and which type of judo throwing technique was used to obtain the score. Throwing techniques were subdivided into leg throws, hip throws, hand throws, and sacrifice throws. Leg, hip, and hand techniques refer to the main body part used to throw the opponent. Sacrifice techniques are throws whereby the attacking judoka drops him/herself on his back first (i.e., "sacrifices" oneself) to execute the

[1] A total of 175 matches were played during the RIO 2016 PG according to the official Results Book of the event. However, detailed match data were missing from that same Results Book for eight matches. We are not aware why these data are missing from the Results Book but could not include these matches for some of our analyses. Since all match-related variables were normalised by number of matches, we did not expect the omission of these eight fights to have a significant impact on our results and conclusions.

throw (DAIGO, 2005). The time-motion analysis was based on the time that each action occurred during the match, expressed in seconds of playing time (GUTIÉRREZ-SANTIAGO et al., 2011; GUTIÉRREZ-SANTIAGO et al., 2012; GUTIÉRREZ-SANTIAGO et al., 2020).

For each athlete (winner or loser), we analyzed the match outcome, technical variation, and time-motion using the following variables:

a) Win ratio: the ratio between matches won and matches competed;
b) Throws per match: each judoka's total number of throws throughout the competition awarded with a score divided by the number of matches they competed in;
c) Technical variability ratio: each athlete's total number of different types of throwing techniques awarded with a score (i.e. leg, hip, hand or sacrifice throws) throughout the competition divided by the number of matches they competed in;
d) Index of Qualitative Variation (IQV): the IQV is a measure to assess how much spread there is within a nominal variable. It expresses the ratio between the total number of different values to the maximum number of different values in the distribution (FRANKFORT-NACHMIAS; LEON-GUERRERO, 2016):

$$IQV = \frac{K(100^2 - \sum Pct^2)}{100^2(K-1)}$$

Where:

K = the number of categories (in this study 4: leg, hip, hand, and sacrifice throws)

$\sum Pct^2$ = the sum of the squared percentages for all categories in the distribution

When all cases in the distribution are in a single group, there is no variation (or diversity) and the IQV is 0. In contrast, when the cases in the distribution are distributed evenly across the groups, there is maximum variation and the IQV is 1. For example, an athlete who scores three times using three different type of techniques (e.g. one hand throw, one leg throw and one sacrifice throw) will show a higher technical variability ratio, and a higher IQV, than another athletes who also scored three times, but each time using the same type of technique (e.g. all leg throws). For example for actual scores for the technical variability ratio and the IQV if the athlete had, for instance, taken part in four matches and used in total six scoring throws (hand throws (n=2), hip throws (n=1) and sacrifice throws (n=3)), their technical variability ratio would be 0.75 and their IQV would be 0.81.

e) Total match time: average time from start to end of the match, including the pauses (i.e. *mate*) (measured in seconds);

f) Time to reach score: average time taken to obtain each scoring throw (measured in seconds);
g) Time to receive penalty: average time taken to receive each penalty (measured in seconds).

Statistical analysis

The normal distribution of the variables was confirmed using the Kolmogorov-Smirnov test. The relationship between the win ratio and throws per match, and between the win ratio and the measures of technical variation (technical variability ratio and IQV) were assessed using Pearson correlation coefficients, adopting the criteria proposed by Hopkins (2002): r = 0−0.1 (trivial), 0.1−0.29 (small), 0.3−0.49 (moderate), 0.5−0.69 (large), 0.7−0.89 (very large) and 0.9−1.0 (almost perfect). One-way analysis of variance (ANOVA) and Tukey post-hoc tests were used to compare the win ratio, throws per match, measures of technical variation (technical variability ratio and IQV) and time-motion variables (total match time, time to reach score, and time to receive penalties) between athletes from the different sport classes (B1, B2 and B3). Effect sizes for ANOVAs were calculated using partial eta squared (η_p^2), using 0.01, 0.06, and 0.14 as small, medium, and large effects (Cohen, 1988). Significant associations were followed-up using post-hoc analysis of the adjusted residuals using Tukey corrections (MACDONALD, ; GARDNER, 2000). The significance level was set at 0.05.

Results

In the matches between B1 and B2 athletes, B1 athletes won 30.8% of matches and B2 won 69.2% of matches. In the matches between B1 and B3 athletes, B1 won 40.9% and B3 won 59.1%. Finally, in the matches between B2 and B3 athletes, B2 won 48.3% and B3 won 51.7%. A Chi squared analysis showed there to be no significant association between B2 and B3 athletes in the distribution of the matches won and lost against B1 athletes ($\chi^2(1) = 0.54$, $p = 0.46$), i.e. there is no significant difference between B2 and B3 in percentage of matches won and lost when fighting B1.

Very large positive correlations were found between the win ratio and throws per match ($r = 0.73$, CI: 0.64 – 0.80, $p<0.001$) and between the win ratio and technical variability ratio ($r = 0.76$, CI: 0.68 – 0.83, $p<0.001$), in addition to a large correlation between the win ratio and IQV ($r = 0.57$, CI: 0.45 – 0.68, $p<0.001$).

Figure 1 shows the comparison of the win ratio, throws per match, technical variability ratio, and index of qualitative variation (IQV) among athletes allocated to the three sport classes. Significant differences between classes were found for the win ratio ($F_{(2,126)} = 4.40$, $p = 0.01$, $\eta_p^2 = 0.07$ [medium effect]), throws per match ($F_{(2,126)} = 3.61$; $p = 0.03$; $\eta_p^2 = 0.05$ [medium effect]) and technical variability ratio ($F_{(2,126)} = 5.44$, $p = 0.005$, $\eta_p^2 = 0.08$ [medium effect]). Post-hoc testing revealed that the win ratio, throws per match, and technical variability ratio were significantly higher for the B2 athletes compared to the B1 athletes (win ratio: p=0.01; throws per match: p=0.03; technical variability ratio: p=0.007). A similar pattern was observed for the B3 athletes when competing against B1, however only the technical variability ration was significantly higher for the B3 athletes (p=0.01), while the differences for win ratio (p=0.06) and throws per match (p=0.09) were not significant. No significant differences were identified for the win ratio, throws per match and technical variability ratio between the B3 and B2 athletes when competing against each other (win ratio: p=0.78; throws per match, p=0.85; technical variability ratio, p>0.99). A similar pattern for IQV was found, with higher values for B2 and B3 compared to B1, but these differences were not significant ($F_{(2,126)} = 1.97$, $p = 0.14$, $\eta_p^2 = 0.03$ [small effect]).

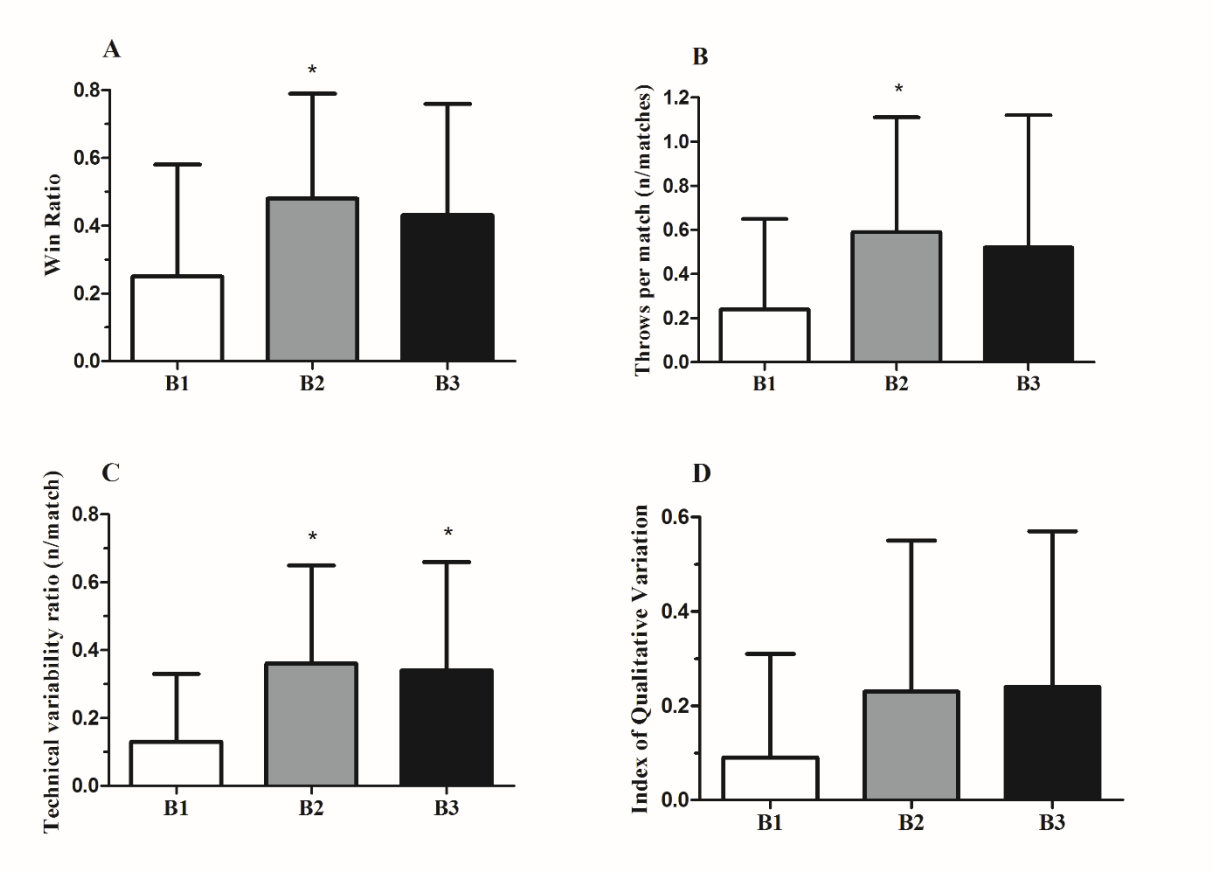

Figure 1. Technical variation among athletes of different sport classes. (A) Win ratio; (B) throws per match; (C) technical variability ratio; and (D) Index of Qualitative Variation across different sport classes in Rio 2016 PG. *Significant difference from B1 class.

Figure 2 presents a comparison of the time-motion variables (total time, time to reach score and time to receive penalties) between the sport classes. No significant differences were found between classes for any of the time-motion variables (time to reach score: $F_{(2,126)} = 0.97$, $p = 0.38$, $\eta_p^2 = 0.01$ [small effect]; total time: $F_{(2,126)} = 1.15$, $p= 0.89$, $\eta_p^2 = 0.02$ [small effect]); time to receive penalties: $F_{(2,126)} = 0.80$, $p= 0.45$, $\eta_p^2 = 0.01$ [small effect]).

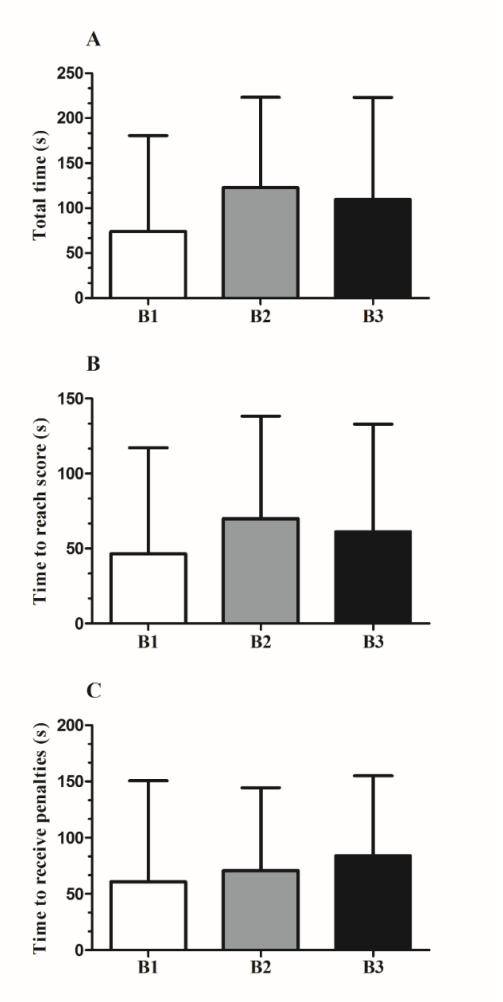

Figure 2. Time-motion analysis among athletes of different sport classes. (A) Total time; (B) time to reach score; and (C) time to receive penalties.

Discussion

The aim of this study was to investigate the relationship between Para sport class and technical variation, time-motion variables, and performance in Paralympic judo. We found that functionally blind athletes (in the B1 class) demonstrated less technical variation in the Rio 2016 Paralympic Games than their partially sighted counterparts (class B2/B3), and that athletes who showed less technical variation were also less successful in competition. The results suggest that measures of technical variation hold promise as a means of evaluating performance in VI judo, particularly for evaluating the relationship between impairment and performance in evidence-based classification research.

It has been previously established that functionally blind athletes are less successful in Paralympic judo compared to those with some residual visual function (KRABBEN et al., 2018;

MASHKOVSKIY et al., 2019; KRABBEN et al., 2020). However, little was known about the relationship between the technical variation in their performance and the competitive success of athletes with more severe vision impairment (KRABBEN et al., 2018; KRABBEN, et al., 2019a). The current results show that athletes who are functionally blind perform less throws per match, and demonstrate less variation in their throwing techniques. The technical variability ratio appears to be a particularly suitable determinant of performance, with an effect size across classes similar in magnitude to that of the win ratio (both a 'medium' effect size) and larger in magnitude of that for the index of qualitative variation (IQV; small effect size). From a performance perspective, the identification of these match-derived variables is important for understanding the competitive profile of Paralympic judo athletes with different degrees of vision impairment and their strategies for achieving scores during the matches.

Even though the overall patterns of results were similar for all performance and technical variation variables when comparing the partially sighted (class B2 and B3) athletes to the functionally blind (class B1) athletes, not all differences were statistically significant (Figure 1). In particular, the current study did not find statistically significant differences in the competitive success (i.e., win ratio [$p = 0.06$] and throws per match [$p = 0.09$]) of B3 athletes when competing against B1 athletes that have been reported in previous research (e.g., KONS et al., 2019; KRABBEN et al., 2020), although we did find differences between B2 and B1 athletes. Given that we found no significant differences in performance between the best (B3) and the worst sighted (B1) athletes, this study might offer support for the current one-class system used in VI judo. However, taking into account that (i) the current study was only based on a single competition, with less B3 athletes than B2 athletes (47 vs 58), (ii) B1 athletes lost the majority (59.1%) of their fights against B3 athletes, and (iii) taking into account the similarity in the overall patterns of performance between B3 and B2 compared to B1 athletes (Figure 1), we consider it unlikely that there is no difference in performance between the B3 and B1 athletes.

Previous research in able-bodied judo suggests that judokas who show more variation in their throwing techniques and, therefore, are less predictable, are more successful in elite judo competitions than judokas who show less technical variation (CALMET; AMAIDI, 2004; FRANCHINI et al., 2008; MIARKA et al., 2015). Our results extend those findings to Paralympic judo and help to explain the disadvantage that functionally blind (B1) judokas appear to experience during international competitions. The ability to functionally adapt to an opponent by switching between different coordination solutions may be considered a crucial

element of expertise (KRABBEN et al., 2019b; KIMMEL; ROGER, 2018; SEIFERT, et al., 2012; FAJEN, et al., 2009; ORTH et al., 2017), and one for which the partially sighted judokas in the B3 and B2 classes have an advantage. An interesting question that is not directly answered by the current study is why functionally blind judokas might be more limited in their technical variation than partially sighted judokas. It might be that some throwing techniques are more visually demanding than others, thereby limiting the range of techniques that blind judokas can execute. Indeed, previous work found that B1 judokas generally favour different types of throwing techniques to B2/B3 judokas (KONS et al., 2019). An alternative (or complementary) explanation might be that blind judokas may require more time and effort to acquire new skills (KRABBEN et al. 2019a), and that the athletes may therefore be more limited in developing proficiency in different throwing techniques.

We found no significant differences in the time-motion variables (total time, time to reach score and time to receive penalties) between athletes of different sport classes in the Rio 2016 PG. These findings suggest that the time-motion variables analyzed in our study do not discriminate Paralympic judo athletes of different classes, or at least that those measures are less sensitive than others which were significant. Thus, the time-motion variables analyzed in this study seem less suitable as measures of performance in VI judo.

Some limitations are inherent in the current study, as only a single competition was investigated and we did not control for the level of vision impairment of each player's opponent. Although we don't expect any bias in the quality of the opponents in early rounds, there may be a bias in the latter rounds because B1 athletes are less likely to progress to those rounds. Accordingly, if anything, the magnitude of any effects we found may be underestimated because the B2 and B3 athletes may be, on average, more likely to compete against other B2 and B3 athletes who make it past the initial rounds. Perhaps most importantly, it was not possible to quantify the relationship between performance and the exact measure of vision impairment (e.g. visual acuity and visual field) because detailed information about each athlete's visual acuity and visual field were not publicly available. Instead, we compared measures of performance among the three sports classes (B1, B2 and B3) as a proxy for their level of impairment because all athletes were classified according to their visual acuity or visual field by International classifiers leading up to the competition.

This approach of comparing classes allows us to verify which measures of performance might be suitable as candidate measures of performance for further research; however, the approach does not allow us to make conclusions about the future class structure of competition

(TWEEDY et al., 2016). While our results are consistent with existing research which suggests that VI judo should be split into (at least) two classes, it remains possible that there is a subset of athletes in the B2 class who are disadvantaged, or even that the B1 class should be further subdivided into separate classes. Studies that specifically compare measures of impairment with performance will be required to provide definitive evidence about the most appropriate number of classes for VI judo and their class structure. Recently, Krabben et al. (2020) related measurements of VA and VF obtained in classification to the competitive success (i.e., win ratio) of elite VI judokas over a period of 8 years. The results of that study also supported a two class system, and suggested a cut-off between classes in the range of 2.0 to 3.5 logMAR. To further narrow down to a specific cut-off point between classes, measures of technical variation appear to be suitable determinants of performance. Another potential limitation of both the current work, as well as the study by Krabben et al. (2020), is that these studies are based on measures of visual function currently used in classification (i.e., VA and VF), whereas a panel of experts in VI judo expressed the opinion that other or additional measures of visual function, such as contrast sensitivity or motion perception, might be required to more appropriately classify VI judokas (KRABBEN et al., 2019a). However, recent research comparing different measures of visual function in VI judo suggests that VA remains the most important predictor of performance (KRABBEN et al., in press).

Conclusion

We conclude that the main match-derived variables that differentiate Paralympic judo athletes with different degrees of vision impairment degrees are throws per match, technical variability ratio and win ratio, which tend to be better in B2 and B3 athletes than B1 athletes. Paralympic judo athletes who had higher levels of technical variation in their throws during competition were more successful during the Rio 2016 PG.

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References

The references of the paper are at “references section” page 103.

5.3 Study 3

Psychometric suitability of adaptations to the special judo fitness test for athletes with visual impairment

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Abstract

This study aimed to test the reliability, sensitivity, construct and logical validity of an adapted Special Judo Fitness Test (SJFT) for judo athletes with visually impairment. Twenty judo athletes with visual impairments performed both the adapted SJFT with tactile and sonorous stimuli (experimental conditions) and the typically administered SJFT (standard condition). We used analyses of variance (ANOVAs) with repeated-measures to compare the groups' SJFT performances, and one-way ANOVAs to compare different visual ability classes of athletes (B1, B2 and B3). We used t-tests to compare SJFT variables between elite and sub-elite groups. We set statistical significance for all tests at $p<0.05$. The standard SJFT showed excellent test-retest reliability for number of throws and overall index (ICC=0.91–0.95), and both sonorous and tactile sensitivity adaptations of the SJFT showed medium sensitivity for detecting performance changes. The number of throws and SJFT index were higher with the sonorous adaptation of the test, compared to the tactile and standard versions ($p<0.001$). Athletes who were blind (B1) presented similar performances to athletes who were partially sighted (B2 and B3) only on the SJFT with the sonorous stimulus. Moreover, only the sonorous SJFT adaptation discriminated between the performances of elite and sub-elite athletes ($p<0.001$). In conclusion, both SJFT adaptations showed excellent reliability and medium sensitivity on test-retest, but, only the SJFT with the sonorous stimulus seemed valid for assessing judo athletes with varying degrees of visual impairment, and only the sonorous stimulus SJFT discriminated elite from sub-elite athletes.

Keywords: performance assessment, blind athletes, combat sports, Paralympics.

Introduction

Monitoring athletes' physical fitness is essential to the training process, as it provides important information about the trainee's current performance to help control-training loads and achieve maximum competitive performance (CURRELL; JEUKENDRUP, 2008; CHAABENE et al., 2018; TAVRA et al., 2016). For this reason, generic and specific tests have been widely used; but, considering the specificity principle, field-testing may be best in competitive sports, as it increases ecological validity (CHAABENE et al., 2018). In judo, for example, several specific tests have been proposed and analyzed by reviewers (CHAABENE et al., 2018; DETANICO; SANTOS, 2012), as these tests aim to estimate indirectly the athlete's physical capacities by considering the judo match time-motion and specific skills (FRANCHINI et al., 2011; TAVRA et al., 2016). Among these tests, the Special Judo Fitness Test (SJFT) has been the most widely used field test over the last 20 years (STERKOWICZ-PRZYBYCIEŃ et al., 2019).

The SJFT partially reproduces the time-motion structure of a judo match and is divided into three periods (A = 15 seconds, B and C = 30 seconds) with 10 second intervals between them (STERKOWICZ et al., 1999). Each partner should be positioned six meters apart, and the executant should run to each partner to throw him/her as many times as possible. The SJFT indirectly estimates the athletes' aerobic capacity (heart rate after the test) and anaerobic capacity (number of throws) (HESARI et al., 2014; STERKOWICZ; FRANCHINI, 2001), and it has been reported to be predominantly anaerobic, although there have been higher values of oxygen uptake during the test (FRANCHINI et al., 2011). In addition, this test has distinguished between athletes of different competitive levels (FRANCHINI et al., 1998; KATRALLI; GOUDAR, 2012) and weight categories (STERKOWICZ; FRANCHINI, 2001), and it has detected changes in physical performance after a periodized training program (MARQUES et al., 2017).

Despite the validity and usefulness of the SJFT for judo athletes (STERKOWICZ-PRZYBYCIEŃ et al., 2019), a version aimed for visually impaired judo athletes has not yet been proposed. Judo for athletes with visual impairment, currently present at the Paralympic Games and international judo championships, has many similarities to conventional (Olympic) judo (e.g., rules and weight categories) (INTERNATIONAL PARALYMPIC COMMITTEE – IPC, 2020). The main particularities of judo for athletes with visual impairment are: (a) the match initiates with athletes positioning their grips on the opponents' *judogi* (judo uniform), and this procedure is repeated every time the combat is interrupted; (b) there is a system that

divides the athletes according to the degree of their visual impairments (i.e., B1 refers to athletes who are totally blind; while B2 and B3 refer to those who are partially sighted) (IPC, 2020).

In other Paralympic sports involving athletes with visual impairments (e.g., goalball and football five), specific adaptations have been proposed, such as clapping hands (a sound signal widely used to guide visual impaired athletes) or tactile stimulation of the foot (ALVES et al., 2018; FINOCCHIETTI et al., 2019; GOULART-SIQUEIRA et al., 2019). People with visual impairment are know to have compensatory increases in auditory functioning (HÖTTING; RÖDER, 2009; MUCHNIK et al., 1991) and in tactile perceptual functioning (RÖDER; RÖSLER, 2004). They have the ability to locate themselves through both sounds (BROSS; BORENSTEIN, 1982) and tactile stimuli, especially through the body's extremities (hands and feet), which represent their first contact on an external surface (RÖDER; RÖSLER, 2004). Thus, adaptations to the SJFT that add needed sound or tactile stimuli, may provide an important strategy for assessing the physical skills of judo athletes with visual impairment. Such adaptations may help these athletes achieve their maximal physical performance, especially during the SJFT phases that involve running and approaching the opponent. However, this has not been tested empirically, and it remains uncertain whether sound or tactile stimuli may have the same effect for different individuals with varying degrees of visual impairment (i.e., blind versus partially sighted) or whether sound or tactile modifications to the SJFT will be the most appropriate adaptations for athletes with visual impairments.

A valid and reliable adaptation of the SJFT for judo athletes and practitioners with visual impairment may provide coaches with an important tool with high ecological validity for monitoring performance, verifying training effects and discriminating athletes of different competitive levels (i.e. professional elite athletes with international level *vs.* sub-elite with national titles) (SWANN et al., 2015). Moreover, it is essential to ensure that this field test is useful for judo athletes with different degrees of visual impairment (B1, B2 and B3). Identifying the specific characteristics and needs of judo participants in different Paralympic classes of visual impairment with specifically different physical performances would contribute to the competitive system in Paralympic vision sports by accurately grouping competitors (KONS et al., 2019). Based on these considerations, we proposed to test reliability, sensitivity, construct and logical validity of two SJFT adaptations (with sonorous and tactile stimuli) for judo athletes with visual impairment.

Method

Study Design

We first measured the reliability and sensitivity (consistency and agreement) of the adapted SJFT with a test-retest design. We then evaluated construct validity between two competitive levels of participant groups (elite and sub-elite) and between participants in varied Paralympic classes defined by their degree of visual impairment (B1, B2 and B3). Finally, we assessed logical validity based on judo coaches' opinions of the best SJFT adaptation for judo athletes with visual impairment.

Participants

Twenty judo athletes with visual impairment participated in this study (Males = 11; M_{age} = 31.8 years, *SD*= 9.1; $M_{body\ mass}$ = 89.6 kg, *SD*= 21.6; M_{height} = 178 cm, *SD*= 5; $M_{years\ of\ judo\ experience}$ = 10.5, *SD*= 11.5; and Females = 9; M_{age} = 28.4 years, *SD*= 6.9; $M_{body\ mass}$ = 66.4 kg., *SD*= 20.2, M_{height} = 164 cm, *SD*= 9; $M_{years\ of\ judo\ experience}$ =12.9 *SD*= 9.1). All athletes competed in judo tournaments in different Paralympic classes of visual impairment (B1= 8, B2= 6 and B3= 6. Twelve athletes were members of the Brazilian Paralympic Judo Team – elite (Males = 5, Females= 7; $M_{years\ of\ judo\ experience}$ =16.9, *SD*= 10.7) and eight athletes were members of the national sub-elite team (Males = 6, Females= 2; $M_{years\ of\ judo\ experience}$ = 4.3, *SD*= 2.3).

Elite Paralympic athletes in this study were comparable to elite participants in Swann et al. (2015) who were defined as: (a) currently receiving support/funding through the international carding scheme, and/or (b) official members of a national/professional team, and/or (c) ranked internationally in their sport. While sub-elite Paralympic athletes were those who compete at university, state and national levels of organized sport, and who trained and competed for a combined minimum of 400 min per week (Swann et al., 2015). We verified that elite judo athletes showed a longer period of prior experience than did sub-elite counterparts (*p*=.006, ES=1.42 [large]).

We selected participants based on the following criteria: (a) no reported musculoskeletal disorder or injury that influenced their maximal physical performance and regular training for at least a year, and (b) currently in the preparatory competition phase and therefore, not in a period of rapid weight loss. During the assessments, the air temperature ranged from 22 to 24°C in the *dojo* (judo-specific training place) on all days of the study.

Special Judo Fitness Test

All athletes performed the unadapted SJFT (standard) on the first day of the study; and, 24 hours later, all athletes performed the SJFT with tactile and sonorous stimuli adaptations on the same day, with these different adaptations randomized in their order, within a 2-hour interval. All athletes then repeated both the standard and adapted SJFT tests 48 hours later (re-testing). To control for the influence of residual fatigue in executing the SJFT, we applied the perceived recovery status survy (Laurent et al., 2014) between intervals of the different SJFT conditions. All athletes responded as "very well recovered / highly energetic" after the 24-hour interval for the SJFT standard, as well as between the two stimuli adaptations of the SJFT (tactile and sonorous). In the latter case, the athletes reported full recovery in the 40-90 minute interval; however, we established a fixed 2-hour recovery interval for all athletes.

There was a standard procedure followed by all athletes in all the various SJFT testing conditions. Namely, athletes performed 5-minute warm-ups, consisting of jogging, judo breaking falling techniques (*ukemi*) and repetitive throwing techniques without falling (*uchi-komi*). Subsequently, three athletes of similar body mass and height performed the SJFT according to the following protocol: two judokas positioned themselves six meters from each other, while the executor was positioned three meters fom them for the throw. The procedure was divided into three periods: 15 seconds (A), 30 seconds (B), and 30 seconds (C) with 10-second intervals between the periods. In each period, the executor threw the opponents using the *ippon-seoi-nage* technique as many times as possible. Evaluations of their performance were based on the total throws completed during each of the three periods (A + B + C). Heart rate (HR) was measured before the test (HR_{REST}), immediately after (HR_{FINAL}) and then, one minute later (HR_{1MIN}) with a HR monitor (Polar® M430, Kempele, Finland). The SJFT index was calculated by dividing the sum of the HR (immediately after the test and one minute later) by the total number of throws (FRANCHINI et al., 2009). The $SJFT_{TT}$ is an indirect indicator of anaerobic capacity, whereas the $SJFT_{HR}$ is an indicator of aerobic capacity; finally, the $SJFT_{INDEX}$ considers two aspects of the test (HR and $SJFT_{TT}$), making it an aerobic/anaerobic marker (STERKOWICZ et al., 1999).

For the adapted SJFT with tactile stimulus we used cord taped to the floor (Tape White, 36 turns, Arnhem, Netherlands) to create a textured line on the ground (official judo mat). This cord had a width of 48 mm and, according to the International Blind Sports Federation (IBSA) regulations, and it was firmly fixed to the floor (a similar taped mat was used during training in

goalball). In the dojo (specific place of judo training) approximately 10 lines were allocated on the floor to create a 30 cm wide space for the test. During all the sets, the athletes performed the test on this line. To adapt the SJFT with a sonorous stimulus, the executor was guided by clapping from the athlete who received the technique during the three sets. About three to five claps were performed until the executant performed the technique. Finally, in the standard condition, the athletes performed the test with no adapted stimuli.

Panel review

Twenty-six judo coaches (M_{age} = 37.8 years, *SD*= 10.1; and $M_{\text{years of practical experience}}$ = 22, *SD*= 10) who work regularly with athletes who have visual impairment participated in logical validity testing. They answered a panel of four questions related to the use of SJFT and its adaptations for judo for visually impaired athletes. They responded using a Likert-type scale to express their views of the ease/difficulty of performing the test ("very easy," "easy," "difficult," and "very difficult") and the test's usefulness ("very useful," "useful," "a little useful" and "impracticable"). The four questions asked were about: (a) the test's comprehensibility in each adaptation, (b) the applicability of the test (space, material and suitability) to judo athletes and practitioners with visual impairments, and (c) which was the best SJFT version (i.e., tactile stimulus, sonorous stimulus, or none). Each coach completed the survey once through an online form. In addition, athletes with visual impairment who performed the SJFT adaptations were asked about their perceptions, and they answered which was the best test after performing all the conditions.

Statistical Analyses

Data were reported as means (*M*) and standard deviations (*SD*). We used the Shapiro-Wilk test to verify normality of the data distribution, confirming a normal distribution for the entire data set and according to Paralympic classes and group competitive levels ($p>.05$). We also tested the proportion of athletes of each sex (male and female athletes) and competitive levels (elite and sub-elite) using the Chi-square test, and found no significant association ($p=.14$), indicating no risk of bias from analyzing both sexes together.

We used the Intraclass Correlation Coefficient (ICC) for consistency type to assess the relative test-retest reliability, and typical error of measurement (TEM) as the indicator of absolute reliability (WEIR, 2005). The TEM was calculated by dividing the standard deviation (*SD*) of the difference between the test-retest trials by $\sqrt{2}$ with a 95% confidence interval (CI)

(HOPKINS, 2000), and expressed it in absolute values and as a coefficient of variation (CV). The smallest worthwhile change (SWC) was also calculated, considering small, medium, and large effect sizes (0.2, 0.6 and 1.2, respectively) (COHEN, 1988). The SWC was assumed by multiplying the between-subject SD by 0.2, 0.6 and 1.2 using the consecutive pairwise analysis of trials for a reliability spreadsheet, as elaborated by Hopkins, and the sensitivity of each variable was assessed by comparing the SWC score with the TEM (HOPKINS, 2000). Thus, if the TEM was higher than the SWC, the effect was "marginal;"; TEM similar to the SWC was "medium;" and a TEM less than the SWC was "good" for detecting small, medium and large differences, respectively (HOPKINS, 2018).

To present the results of the panel review, we used simple frequency counts. We used an independent samples t-test to compare the SJFT performance between the elite *vs*. sub-elite participants. We used analyses of variance (ANOVAs) for repeated measures with Bonferroni as a post-hoc test to compare the SJFT variables between different conditions (standard, tactile and sonorous stimuli); and we used sone-way ANOVA (between-subjects) to compare the SJFT variables between different Paralympic classes (B1, B2 and B3). We calculated the effect size (ES) from ANOVAs with partial eta squared (η_p^2), expressed by the variance of the sums of squares for a particular effect (treatment) relative to the sum of squares of that effect plus the error sum of squares (error), considering the treated value as a proportion from 0 to 1. The classification criterion for partial eta squared ES was: 0.01 to 0.06 (small effect), 0.06 to 0.14 (medium effect) and ≥ 0.14 (large effect) (COHEN, 1969; COHEN, 1973; DAHLAN et al., 2009). For the t-test we used the Cohen's *d,* considering 0.0–0.25 as trivial, 0.21–0.65 as small, 0.61–1.2 as moderate, 1.21–2.0 as large, and 2.1–4.5 as very large (Hopkins, 2002). We used the JASP software (version 0.11.1, JASP team, University of Amsterdam, Netherlands) for analyses, and se the statistical significance level at 5% (Type I error) and the statistical power (β) higher than 0.8 (Type II error).

Results

Reliability and sensitivity of the adapted SJFT

Table 1 shows the measures of reliability and sensitivity of the variables obtained in the adaptation of SJFT with the tactile stimulus. The ICC values were excellent for the number of throws and index, while for the HR_{FINAL} and HR_{1MIN} the ICC was fair-to-good. The $SWC_{0.6}$ was higher than TEM (medium difference) for SJFT number of throws, index and HR_{FINAL}.

However, it is important to note that the TEM of the SJFT index was above the upper confidence interval. For HR_{1MIN}, only $SWC_{1.2}$ was higher than the TEM (marginal difference).

Table 1. Test-retest values (mean ± SD) and scores of reliability and sensitivity of the variables obtained during SJFT with tactile stimulus.

	Test	**Retest**	**ICC (95% CI)**	**TE (95% CI)**	**$SWC_{0.2}$**	**$SWC_{0.6}$**	**$SWC_{1.2}$**
$SJFT_A$ (n)	4 ± 0	4 ± 0	0.91 (0.78-0.96)	0.33 (0.26-0.46)	0.15	0.46	0.92
$SJFT_B$ (n)	7 ± 1	8 ± 1	0.93 (0.83-0.97)	0.65 (0.52-0.89)	0.29	0.86	2.20
$SJFT_C$ (n)	7 ± 1	7 ± 1	0.91 (0.79-0.96)	0.53 (0.42-0.73)	0.23	0.69	1.38
$SJFT_{TOTAL}$ (n)	19 ± 3	20 ± 4	0.94 (0.85-0.97)	1.26 (1.00-1.73)	0.57	1.72	3.44
Index	17 ± 4	16 ± 4	0.95 (0.89-0.98)	1.06 (0.84-1.45)	0.67	2.01	4.02
HR_{FINAL} (bpm)	173 ± 10	172 ± 11	0.76 (0.41-0.90)	6.47 (5.14-8.87)	1.88	5.64	11.27
HR_{1MIN} (bpm)	150 ± 11	149 ± 13	0.77 (0.44-0.91)	7.44 (5.91-10.1)	2.64	7.91	15.82

SJFT= Special Judo Fitness Test; HR= heart rate; n= number of throws; ICC = Intraclass Correlation Coefficient (all significant at $p < 0.05$); TE = typical error 95% confidence interval; SWC = smallest worthwhile change (0.2, 0.6 and 1.2 – small, medium and large effect sizes, respectively);

Table 2 shows the measures of reliability and sensitivity of the variables obtained in the adaptation of SJFT with the sonorous stimulus. The ICC values were excellent for the number of throws (all sets), index, HR_{FINAL} and HR_{1MIN}. The $SWC_{0.6}$ was higher than TEM (medium difference) for SJFT number of throws and index, although it was slightly higher than the TEM upper confidence interval. For the HR measures, the $SWC_{1.2}$ was higher than the TEM (marginal difference).

Table 2. Test-retest values (mean ± SD) and scores of reliability and sensitivity of the variables obtained during SJFT with sonorous stimulus.

	Test	Retest	ICC (95%CI)	TE (95%CI)	$SWC_{0.2}$	$SWC_{0.6}$	$SWC_{1.2}$
$SJFT_A$ (n)	4 ± 0	4 ± 0	0.93 (0.92-0.99)	0.22 (0.17-0.30)	0.17	0.50	1.00
$SJFT_B$ (n)	8 ± 2	7 ± 1	0.92 (0.81-0.97)	0.76 (0.61-1.05)	0.37	1.10	2.20
$SJFT_C$ (n)	7 ± 1	7 ± 1	0.91 (0.87-0.98)	0.63 (0.50-0.86)	0.24	0.71	1.42
$SJFT_{TOTAL}$ (n)	20 ± 6	20 ± 2	0.95 (0.89-0.98)	1.29 (1.02-1.76)	0.68	2.03	4.06
Index	17 ± 4	16 ± 4	0.95 (0.87-0.98)	0.98 (0.78-1.34)	0.73	2.18	4.36
HR_{FINAL} (bpm)	176 ± 9	174 ± 8	0.82 (0.56-0.93)	5.36 (4.26-7.35)	1.51	4.53	9.05
HR_{1MIN} (bpm)	155 ± 10	153 ± 11	0.90 (0.75-0.96)	7.94 (6.30-10.8)	1.60	4.80	9.60

SJFT= Special Judo Fitness Test; HR= heart rate; n= number of throws; ICC = Intraclass Correlation Coefficient (all significant at $p < 0.05$); TE = typical error 95% confidence interval; SWC = smallest worthwhile change (0.2, 0.6 and 1.2 – small, medium and large effect sizes, respectively).

Comparison of the participant performances on the adapted SJFT (experimental conditions) and the standard SJFT

Table 3 summarizes the comparison of SJFT variables obtained from different conditions (standard and adaptations for tactile and sonorous stimulus) among judo athletes with visual impairment. The SJFT performance (number of throws) was higher in the sonorous condition than in the standard SJFT condition, $SJFT_A$ ($p<.001$, $p=.05$), $SJFT_B$ ($p<.001$, $p=0.04$) and $SJFT_{TOTAL}$ ($p<0.001$, $p=0.006$, respectively). The tactile condition was higher than the standard condition for $SJFT_A$ ($p=.030$), $SJFT_B$ ($p<.001$), $SJFT_C$ ($p<.001$) and $SJFT_{TOTAL}$ ($p<.001$). The index was lower in the sonorous and tactile conditions compared to the standard condition ($p<.001$ for both comparisons). The HR_{FINAL} and HR_{1MIN} in the tactile condition were

lower than in the standard condition (p<.001, p=.002, respectively). There was no significant difference between conditions in the HR_{REST} at pre-test values or at the HR variation points (ΔHR_{FINAL}-ΔHR_{REST} and ΔHR_{1MIN} - HR_{REST}).

Table 3. Comparison of SJFT variables obtained from different conditions (standard, tactile and sonorous stimulus) in athletes with visual impairment.

Performance	Standard	Tactile	Sonorous	F	η_p^2	ES	P
$SJFT_A$ (n)	4 ± 1	4 ± 1*	5 ± 1*#	18.48	.493	Large	<.001
$SJFT_B$ (n)	7 ± 2	8 ± 2*	9 ± 2*#	20.48	.519	Large	<.001
$SJFT_C$ (n)	6 ± 1	7 ± 1*	8 ± 2*	16.91	.471	Large	<.001
$SJFT_{TOTAL}$(n)	17 ± 3	19 ± 3*	21 ± 4*#	40.78	.682	Large	<.001
Index	20.4 ± 4.9	17.6 ± 3.8*	16.8 ± 4.3*	36.96	.660	Large	<.001
HR_{REST} (bpm)	86 ± 6	86 ± 5	86 ± 6	2.02	.001	Small	.990
HR_{FINAL} (bpm)	177 ± 10	173 ± 10*	176 ± 9	4.34	.186	Large	.020
HR_{1MIN} (bpm)	157 ± 11	149 ± 11*	155 ± 10	7.52	.284	Large	.002
ΔHR_{FINAL}-HR_{REST} (bpm)	90 ± 11	86 ± 12	89 ± 11	0.55	.019	Small	.577
ΔHR_{1MIN}-HR_{REST} (bpm)	70 ± 12	63 ± 13	68 ± 10	2.02	0.06	Small	.141

ES = effect size; HR= heart rate; n= number of throws; Δ= delta; *Different from control. #Different from tactile adaptation.

Comparison of performance on the adapted SFJT among the participant Paralympic sport classes denoting degree of visual impairment (B1, B2 and B3)

The comparison of SJFT variables obtained from different conditions (SJFT standard and SJFT adaptations for tactile and sonorous stimuli) among the Paralympic sport classes (B1, B2 and B3) is presented in Table 4. In the standard condition, $SJFT_C$ was higher in B2 (p=.003)

and B3 (p=.050) compared to B1, and the index was lower in B2 (p=.037) and B3 (p=.050) compared to B1. In the tactile condition, $SJFT_C$ and $SJFT_{TOTAL}$ were higher in B2 in comparison to B1 (p=.031, p=0.049, respectively), and the index was lower in B2 and B3 athletes compared to B1 (p=.050 for both comparisons). There were no significant differences in SJFT variables adapted from sonorous stimulus among the Paralympic sport classes.

Table 4. Comparison of SJFT variables obtained from different conditions (standard and adaptations for tactile and sonorous stimulus) among the sport classes.

	B1	**B2**	**B3**	**F**	η_p^2	**ES**	**P**
Standard							
$SJFT_A$ (n)	3 ± 1	4 ± 1	4 ± 0	1.65	.163	Large	.220
$SJFT_B$ (n)	6 ± 1	7 ± 2	7 ± 2	2.21	.207	Large	.140
$SJFT_C$ (n)	5 ± 1*#	7 ± 1	7 ± 1	8.18	.491	Large	.003
$SJFT_{TOTAL}$ (n)	14 ± 3*	19 ± 3	18 ± 2	4.16	.329	Large	.034
Index	24.1 ± 5.2*#	17.8 ± 3.7	18.2 ± 2.4	5.16	.378	Large	.018
HR_{FINAL} (bpm)	180 ± 10	177 ± 11	172 ± 8	1.17	.121	Medium	.330
HR_{1MIN} (bpm)	162 ± 11	153 ± 13	155 ± 7	1.37	.139	Medium	.280
Tactile stimulus							
$SJFT_A$ (n)	4 ± 1	5 ± 1	5 ± 1	2.89	.061	Medium	.083
$SJFT_B$ (n)	6 ± 1	8 ± 2	8 ± 1	2.37	.223	Large	.120
$SJFT_C$ (n)	6 ± 1*	8 ± 1	7 ± 1	4.46	.204	Large	.028
$SJFT_{TOTAL}$ (n)	16 ± 3*	21 ± 3	20 ± 2	3.92	.212	Large	.040
Index	20.3 ± 4.0*#	15.8 ± 3.0	15.8 ± 2.1	4.57	.239	Large	.026
HR_{FINAL} (bpm)	176 ± 11	173 ± 10	170 ± 8	0.61	.071	Medium	.550
HR_{1MIN} (bpm)	154 ± 10	149 ± 15	145 ± 6	1.13	.085	Medium	.340
Sonorous stimulus							
$SJFT_A$ (n)	4 ± 1	5 ± 1	5 ± 1	0.55	.254	Large	.580
$SJFT_B$ (n)	7 ± 2	8 ± 2	9 ± 1	2.43	.219	Large	.110
$SJFT_C$ (n)	6 ± 1	8 ± 1	8 ± 1	2.18	.344	Large	.140
$SJFT_{TOTAL}$ (n)	18 ± 4	21 ± 5	22 ± 1	2.29	.316	Large	.130
Index	19.2 ± 5.1	16.3 ± 3.9	14.2 ± 1.3	2.66	.350	Large	.098
HR_{FINAL} (bpm)	178 ± 10	177 ± 10	173 ± 6	0.65	.068	Medium	.530

HR_{1MIN} (bpm)	157 ± 10	156 ± 10	151 ± 8	0.79	.017	Small	.470

ES = effect size SJFT= Special Judo Fitness Test; HR= hear rate *Different from B2; #Different from B3

Comparison of performances between elite and sub-elite athletes on the adapted SJFT

Figures 1 and 2 show the comparison of SJFT variables obtained from different conditions (standard and adaptations for tactile and sonorous stimulus) between different participant competitive levels (elite and sub-elite). Considering SJFT performance, $SJFT_A$ was higher for elite athletes than for sub-elite athletes in the standard condition (p=.011, ES=1.21 [large]) and the sonorous condition (p<.001, ES=2.35 [very large]), while $SJFT_B$ showed superior values by the elite group than by the sub-elite group in the standard condition (p=.029, ES=1.03 [small]), the sonorous condition (p=.003, ES=1.61 [moderate]) and the tactile condition (p=.007, ES=1.05 [small]). In the $SJFT_C$, the elite group showed higher performance than the sub-elite only for the sonorous condition (p=.007, ES=0.39 [moderate]). For the $SJFT_{TOTAL}$, the elite group showed superior performance compared to the sub-elite group in the sonorous condition (p<.001, ES=2.01 [large]). The HR_{FINAL} was lower among the elite group than the sub-elite group in the standard condition (p<0.001, ES=2.05 [large]), the sonorous condition (p=.001, ES=1.77 [large]) and the tactile condition (p<.001, ES=2.06 [large]), whereas HR_{1MIN} was lower for the elite group compared to the sub-elite group only in the standard condition (p=.040, ES=1.15 [moderate]). Finally, the $SJFT_{INDEX}$ was lower for the elite group compared to the sub-elite group in the standard condition (p=.050, ES=1.00 [small]), the sonorous condition (p=.002, ES=1.95 [moderate]) and the tactile condition (p=.007, ES=1.04 [small]).

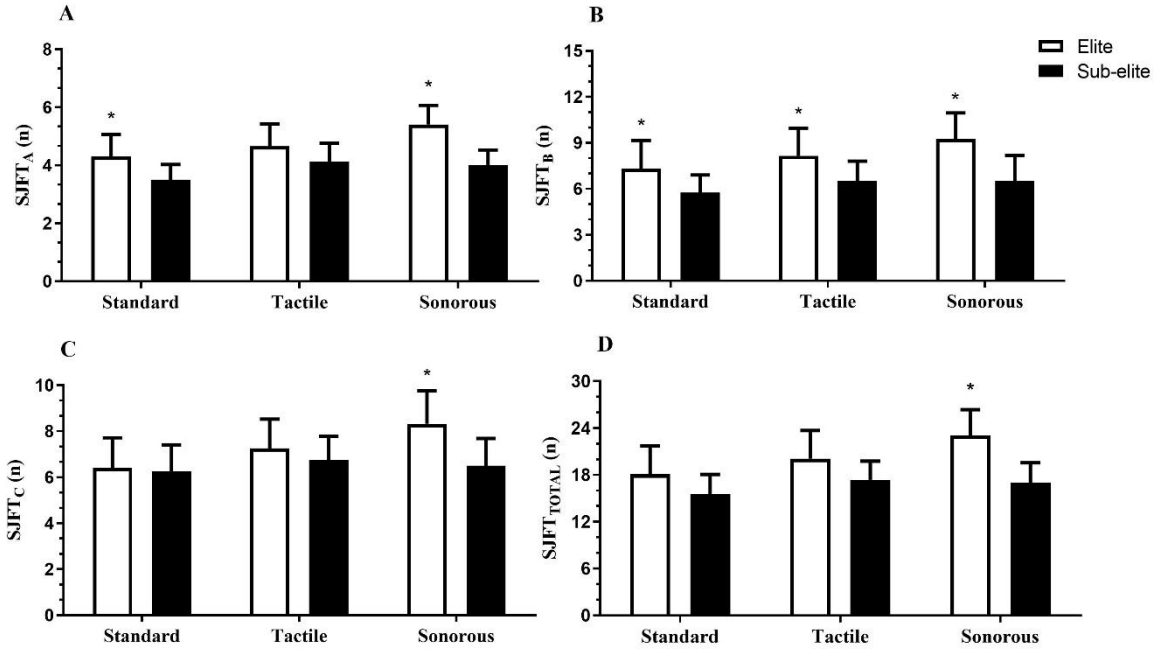

Figure 1. Comparison of Number of Throws Obtained with Different SJFT Versions (standard and adaptations for tactile and sonorous stimulus) between Elite and Sub-elite Judo Athletes with Visual Impairment. Note: *Significantly different from sub-elite.

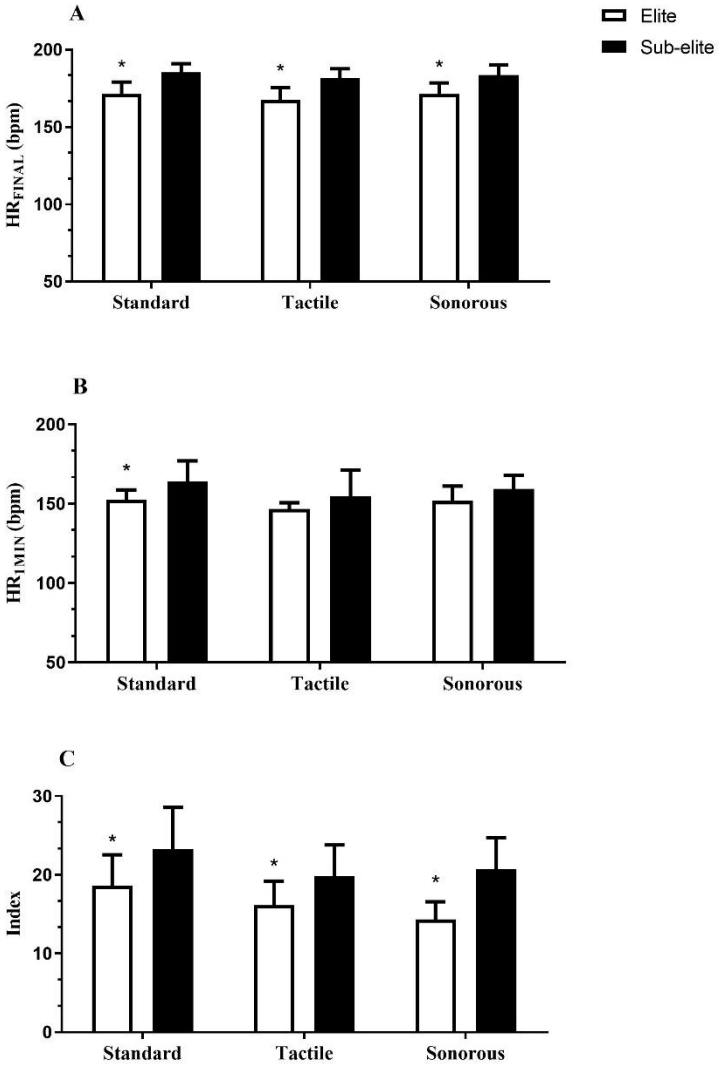

Figure 2. Comparison of SJFT Index and HR Obtained with Different SJFT Versions (standard and adaptations for tactile and sonorous stimulus) between Elite and Sub-elite Judo Athletes with Visual Impairment. Note: *Significantly different from sub-elite.

Panel review results

With respect to the panel review's (judo coaches) opinions about the SJFT adaptations, 61.5% of coaches considered both sonorous and tactile adaptations "very easy" and 38.4% considered the sonorous and tactile conditions as "easy" to understand. Regarding applicability, 61.5% of the coaches considered both the sonorous and tactile adaptations "very useful" and 38.4% considered them "useful." Coaches viewed the sonorous stimulus to be the best adaptation (76.9%), followed by the tactile adaptation (23.1%). Most judo athletes with visual impairments who performed the SJFT adaptations reported that the best adaptation was the

sonorous adaptation (90.0%), while a much smaller percentage viewed the tactile adaptation as best (10.0%).

Discussion

In this study, we aimed to test the reliability, sensitivity, construct and logical validity of the SJFT for judo athletes with visual impairment through two separate adaptations involving either sonorous or tactile stimuli. We found that the participants' SJFT performances (number of throws and index) in both the SJFT adaptations (sonorous and tactile stimuli) were reliable and presented medium sensitivity for detecting performance changes. The judo athletes with visual impairments performed better with, both sonorous and tactile SJFT adaptations, compared to the standard SJFT; but the number of throws and the index score were higher in the SJFT sonorous adaptation, compared to the tactile adaptation. Athletes who were blind presented similar performances to those who were partially sighted only when the sonorous stimulus was applied, showing that this adaptation may be used by athletes with visual impairment, regardless of their level of visual impairment. Moreover, only the sonorous SJFT adaptation could discriminate between the elite and sub-elite athletes in the number of throws (all sets and total), index and HR_{FINAL}. This adaptation was also preferred by both coaches (panel review) and athletes who performed the tests.

Reliability, or the reproducibility of the test's values, is best measured through repeated trials on the same individuals (HOPKINS, 2000). Good reliability implies better precision of single measurements and better tracking of changes in measurements in research or practical settings. The sensitivity shows whether a "real" change has occurred over time or due to a given intervention (HOPKINS, 2000). We verified that SJFT performance variables (number of throws and index) in both sonorous and tactile stimuli adaptations were reliable and presented medium sensitivity (i.e., comparing the SWC with TEM for each variable). The HR measures presented excellent reliability only for the sonorous stimulus adaptation, and showed medium to marginal sensitivity for both test adaptations. Therefore, our results indicate that, although the SJFT adaptations are reliable, the variables have medium sensitivity for detecting changes in performance, especially for the number of throws and index score. Coaches, when analyzing performance changes through the SJFT, should consider this aspect of the test. The measures of HR require caution in all tests, because they showed low sensitivity to detect performance changes. It is known that the HR usually shows large variability (FRANCHINI et al., 2018),

although some environmental aspects were controlled in the current study (e.g., temperature, schedule, data collection and routine).

The athletes with visual impairment had better performance (number of throws and index) on both the sonorous and tactile SJFT adaptations compared to the standard condition, but these variables were superior on the SJFT sonorous test compared to the tactile adaptation. A possible explanation of these results is that individuals who are blind or partially sighted often develop strategies to synthesize the information from auditory and tactile stimuli (BROSS; BORENSTEIN, 1982; HÖTTING; RÖDER, 2009). It is known that blind individuals usually have a high ability to perceive touch, mainly through the body's extremities (i.e., hands and feet) (HÖTTING; RÖDER, 2009; RÖDER et al., 2004). Yet, for motor tasks involving sprint running, as occurs in the SJFT approaching task, the sonorous stimuli may increase orientation ability. A higher reaction time has been found previously for individuals who were blind when they were tested with the sonorous compared to tactile stimuli (SPENCE et al., 1998). Moreover, it is possible that when running on the mat (tactile stimulus), more focus and concentration is required, as athletes should touch it to guide the direction of their running; and, added difficulty may have decreased their orientation ability and, consequently, their sprint performance.

When comparing athletes in different Paralympic sport classes across testing conditions, we observed that B1 athletes performed more poorly than B2 and B3 athletes on the third set of the SJFT, total number of throws and index on both the standard and tactile SJFT adaptations. However, there was no significant performance difference between these Paralympic classes for performances with the sonorous SJFT stimulus. Prior research has already shown that B1 athletes usually have lower competitive success (e.g., scores and medals in official competition) (KONS et al., 2019; KRABBEN et al., 2018; MASHKOVSKIY et al., 2019) and technical-tactical performance (e.g., efficiency and shorter time to lose) than athletes who are partially sighted (KONS et al., 2019), mainly due to their missing field of vision. However, when the sonorous stimulus was used in the SJFT, these performance differences decreased, allowing for more homogeneity (considering their degree of visual impairment) between athletes of different classes. The performance improvements through the sonorous stimulus adaptation may be explained by the mechanisms associated with central auditory skills and temporal auditory acuity compensations in individuals who are blind (BROSS; BORENSTEIN, 1982; HÖTTING; RÖDER, 2009), as discussed previously.

We also tested discriminant validity by comparing athletes of different competitive levels (elite *vs*. sub-elite) on these SJFT versions. On all SJFT variables (with exception of HR_{1MIN}) elite athletes performed better than sub-elite athletes when tested with the sonorous adaptation. With the tactile stimulus adaptation, elite athletes only performed better than sub-elite athletes on the second series of SJFT variables, the index and HR_{FINAL}. Thus, the sonorous SJFT adaptation was able to discriminate different competitive levels, particularly considering the number of throws and index.

Previous studies have already demonstrated that SJFT performance is able to discriminate competitive levels (FRANCHINI et al., 2005; STERKOWICZ; FRANCHINI, 2001; STERKOWICZ-PRZYBYCIEŃ et al., 2019). These finding have usually been attributed to the fact that elite athletes have a higher volume of judo-specific training (DRID et al., 2015) and, consequently, are able to perform better on specific motor tasks like number of throws (FRANCHINI et al., 2005; STERKOWICZ-PRZYBYCIEŃ et al., 2019). The HR measures after the test indirectly estimated the athlete's aerobic fitness (HESARI et al., 2014), but due to its high variability, it may not be a good marker to discriminate groups.

Our panel review provided an indication of the logical validity of the test, and for athletes with visual impairment, these specific assessments have been seen as highly relevant for practical applications (KRABBEN et al., 2019; MANN; RAVENSBERGEN, 2018, RAVENSBERGEN et al, 2016). According to coaches, both SJFT adaptations (sonorous and tactile) are useful and easy to apply to judo athletes. However, almost all athletes with visual impairment who performed the SJFT adaptations preferred the test with sonorous stimuli. Therefore, the test adaptations from different stimuli can be an important measure of physical performance in judo athletes and practitioners with visual impairment. Coaches can use it to identify the individual athlete's profile and monitor physical training through a field test with high ecological validity (CHAABENE et al., 2018; STERKOWICZ-PRZYBYCIEŃ et al., 2019).

Limitations and Directions for Further Research

Among this study's limitations, our small sample size (n=20) is a methodological weakness in our efforts to establish reliability, sensitivity and validity of this adapted test (CHAABENE et al., 2018), as it limited the generalizability of our findings. However, statistical power was acceptable ($\beta > 0.8$) for avoiding type II error. The population of judo athletes with visual impairment is much smaller than that of conventional judo athletes, making

it difficult to conduct a study with a larger sample size. In our study, some elite athletes (male and female) were members of the Brazilian judo team for athletes with visual impairment, increasing the quality of the sample. A second limitation was that we did not measure metabolic variables such as blood lactate concentration and oxygen consumption over the test, though these data could have provided more information about the potential physiological demand differences associated with these SJFT adaptations. Third, for the sonorous adaptation, it was not possible to control the sound decibels during the SJFT evaluation, since the sound stimuli were handclaps to make the application as accessible as possible. However, the use of this simple and popular approach in training conditions was effective for the testing purposes. We recommend future investigators use the adaptations of the SJFT to identify long-term physical performance changes and that they test the SJFT adaptations in athletes among athletes of different weight categories.

Conclusions

In summary, both SJFT adaptations (with tactile and sonorous stimuli) showed excellent reliability and medium sensitivity on test-retest, particularly considering the performance variables (number of throws and index). However, only the SJFT with sonorous stimulus was valid for distinguishing judo athletes with different degrees of visual impairment (B1, B2 and B3). The SJFT with sonorous stimulus was also the only one capable of discriminating elite from sub-elite athletes on all performance variables. Finally, according to the panel review and opinions of judo athletes with visual impairment, the sonorous SJFT adaptation was preferred as useful and easier to apply during training routines. Thus, a simple adaptation (sonorous stimulus provided by the partners) during the SJFT execution may provide a useful and accessible indicator to support strength and conditioning coaches in monitoring physical training throughout the season.

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CHAPTER IV

6. FINAL CONSIDERATIONS

6.1 Brief of Studies Results

This thesis was composed of two studies that focused on the technical-tactical and competitive performance in judo athletes with visual impairment and one study that analyzed the adaptation of SJFT (from tactile and sonorous stimuli) for this population. Our analyses were conducted to identify the possible differences among athletes from the three sport classes (i.e. different degree of visual impairment), as it is believed that each sport class has particularities that must be considered by coaches during the physical training and monitoring, as well as by organizations and competitive systems in order to ensure legitimacy between athletes during official competitions.

Our results indicate a lower performance in scores, technical variation, time-motion and aspects related to the number of medals for B1 athletes compared to B2 and B3 athletes (study 1). This demonstrates evidence that the classification system in Paralympic judo needs to be improved, especially in the competitive system, since the aspects analyzed in this study directly demonstrate the differences of performance between each sport class. In this direction, considering that the number of athletes in class B1 is smaller when compared to B2 and B3, the disadvantages when blind athletes fight against partially sighted competitors during the competitions can be considered a discouraging factor for athletes with greater visual impairment (i.e. B1 class), since it is present in some perspectives related to the competitive environment (e.g. medals, scores, technical variation, etc.).

In the second direction, we also verified the differences in the technical variability of athletes with visual impairment (e.g. B1 have lower performance levels when compared to the B2 and B3) but no difference was found for percentage of wins. The additional technical-tactical components also proved to be different (study 2), demonstrating that athletes with greater visual impairment have a lower win ratio, technical variability and index of qualitative variation during official judo competitions. The variation of judo throwing techniques during the combats are important for obtaining victories during matches, and therefore another disadvantage for blind athletes.

6.2 Practical Applications

From a practical perspective in the accessibility and reachability, the adaptations of the SJFT for athletes with visual impairment, especially through the sonorous stimulus, proved to

be an excellent alternative for coaches and physical trainers to use in the assessment of specific physical capacities (study 3). It is important to emphasize that the adaptations (sonorous and tactile) were carried out using accessible strategies for the adaptation of the test, with the sonorous stimulus using claps to guide the athlete and the tactile one using adhesive tape glued with a line in the judo training space (dojo). Due to the lack of vision, stimuli related to visual and sensory aspects are overcompensated and strategies that consider potentiating these stimuli are a good alternative to help coaches to assess and monitor physical performance considering the actions that can maximize these stimuli.

Finally, based on the findings of this thesis, we can conclude the following aspects: Athletes with greater visual impairment (i.e. B1) have a lower competitive performance compared to athletes with less visual impairment (B2 and B3), but no difference for percentage of victories, demonstrating that the organizational system and the classification of judo athletes in the competitive moments need to be improved. To further support this direction, the technical variation also proved to be inferior for blind athletes compared to the partially sighted, suggesting that the lack of vision is an aspect that may impact on the development of technical-tactical actions of athletes with visual impairment, especially when they fight against partially sighted counterparts. Additionally, we verified in this study that a simple adaptation of a test already validated in the literature (SJFT) and adapted through different sensorial stimuli for blind people is an important assessment tool to be used by coaches during the competitive season, with good indicators of reliability, sensitivity, construct and logical validity (experts opinions by coaches and athletes). It is important to highlight that the SJFT adaptations were applied using very low cost equipment. Thus, SJFT adapted may be accessible to coaches of judo athletes with visual impairment identifying anaerobic capacity physical capacities involved in the some moments of judo combats.

6.3 Limitations of Studies

Some limitations can be highlighted in this study: firstly, we did not explore specific time-motion variables (e.g. time for attacks, time for transitions groundwork and others) in the Paralympic Games (London 2012 and Rio 2016), as the books results were used to identify performance variables in competitions. Secondly, other important world judo competitions (*e.g.* World Championships, Grand Slam and Grand Prix) in athletes with visual impairment were not investigated; however, we chose the highest level-competition (i.e. Paralympic Games). Considering the perspective of SJFT adaptations, the small sample size and the analysis

considering both sexes in the same group are limiting factors in this study. However, the high competitive level of athletes (some from the main Paralympic team in Brazil) and the difficulty in finding athletes with visual impairment that practice judo with a certain level of experience can support the investigation conducted.

6.4 Future Recommendations

For future recommendations based on the findings of this study, we can highlight some points. Investigating the time-motion variables considering a large sample size of matches and to conduct a technical-tactical analysis with more specificity of the actions of judo athletes with visual impairment (e.g. time to grip approach, time to groundwork transition, time to grip dispute and different types of grips during matches). These variables can help to identify a more specific profile of athletes and thus to verify determining actions according to each visual class between medalists and non-medalists. Moreover, identifying the influence of rule changes over years on technical-tactical and competitive performance actions can provide guidance on how judo athletes with visual impairment can adapt to these changes.

An important point to mention is a recent suggestion for classification in Paralympic Judo to consider dividing the athletes into two visual classes (KRABBEN et al., 2020). The authors of this study used measures based on the visual acuity tests to establish the point of cut from 2.5 logMAR. If this type of classification is established by the IPC (it is still in the process of being studied by experts), we recommend investigating competitive and technical-tactical performance of both groups. In addition, to verify if the current classification system (if so assigned) is making the competitive aspects equal (legitimate) among athletes.

Finally, we encourage future studies to propose or adapt performance tests considering low-cost strategies with adaptations based on the senses overcompensating in people with visual impairment, mainly related to the sonorous and tactile stimulus. In addition, we reinforce the need for adaptations of tests that measure the specific capacity of judo athletes (*e.g. uchikomi fitness test*) in order to identify parameters related to the performance of these groups.

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APPENDIX A - TERMS OF INFORMED CONSENT FORM (ICF)

Universidade Federal de Santa Catarina

Centro de Desportos

Programa de Pós-Graduação em Educação Física

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO (TCLE)

Título do projeto: Relação do desempenho competitivo com testes genéricos e específicos em atletas de judô das modalidades olímpica e paralímpica.

Você está sendo convidado a participar como voluntário da pesquisa intitulada "**Relação do desempenho competitivo com testes genéricos e específicos em atletas de judô das modalidades olímpica e paralímpica**", a ser realizada junto aos Laboratórios de Pesquisa vinculados ao Centro de Desportos (CDS) da Universidade Federal de Santa Catarina (UFSC). Com sua adesão ao estudo, você ficará disponível para a pesquisa em dois momentos para as avaliações, organizado da seguinte maneira:

a) Incialmente serão realizadas as medidas antropométricas (massa corporal, estatura e adipometria) e em seguida os atletas realizarão o teste de salto vertical sobre uma plataforma de força e o teste de força de preensão manual. Na sequência serão realizados testes específicos do judô: *Judogi Grip Strength Test* e *Special Judo Fitness Test*, os quais serão devidamente demostrados antes das avaliações.

b) No segundo momento serão realizados novamente os testes de salto vertical e a força de preensão manual no momento pré-competição (1 hora antes), assim como as filmagens das lutas em competição para posterior análise técnico-tática. O intervalo entre as duas avaliações (laboratório e competição) não deve ultrapassar 2 semanas.

As coletas de dados serão realizadas nos seguintes locais: Laboratório de Biomecânica (BIOMEC), dojô de artes marciais e academia de musculação da UFSC. Já as filmagens em competição serão realizadas nos locais específicos das competições conforme estabelecido pelo calendário esportivo da modalidade no Estado.

Para participar deste estudo você deve está apto para realizar exercícios físicos de alta intensidade, semelhante ao que você realiza nos treinamentos. Da mesma forma, deve estar

ciente da possibilidade de apresentar náuseas e vômito em decorrência do esforço na realização dos testes. No entanto, menos de 1% da população americana apresenta desconforto durante este tipo de teste (*American College of Sports Medicine*). Os pesquisadores responsáveis por este estudo estarão preparados para qualquer emergência efetuando os primeiros socorros. A sua identidade será preservada durante todas as avaliações, pois cada sujeito da amostra será identificado por número. As pessoas que estarão lhe acompanhando fazem parte de uma equipe treinada e coordenada pela professora Dra. Daniele Detanico. Quanto aos benefícios e vantagens em participar deste estudo, você estará contribuindo de forma única para o desenvolvimento da ciência esportiva. Os resultados provenientes das analises servirão de diagnóstico de sua atual condição física e desempenho posterior em competição.

Se você estiver de acordo em participar do estudo, garantimos que as informações fornecidas serão confidenciais e só serão utilizadas neste trabalho. Da mesma forma, caso tenha alguma dúvida em relação aos objetivos e procedimentos da pesquisa, ou mesmo, queira desistir da mesma, poderá a qualquer momento entrar em contato conosco pelo telefone (48) 3721-8530 ou pessoalmente nos laboratórios de pesquisa do Centro de Desportos.

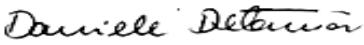
A legislação brasileira não permite que você tenha qualquer compensação financeira pela sua participação em pesquisa, porém você será ressarcido pelas despesas previstas no projeto. Para participar da pesquisa você terá algumas despesas de transporte e alimentação que serão integralmente ressarcidas pelos pesquisadores, assim você não terá nenhuma despesa advinda da sua participação na pesquisa, conforme a Resolução 466/12 de 12/06/2012.

Você também poderá entrar em contato com o Comitê de Ética em Pesquisa com Seres Humanos da UFSC pelo telefone: (48) 3721-6094 e-mail: <cep.propesq@contato.ufsc.br> ou pessoalmente na Rua Desembargador Vitor Lima, nº 222, sala 401, Trindade, Florianópolis/SC CEP 88.040-400, Prédio Reitoria II Universidade Federal de Santa Catarina.

Duas vias deste documento estão sendo rubricadas e assinadas por você, pelo responsável do atleta com deficiência visual e pelo executor do projeto (Rafael Lima Kons). Guarde cuidadosamente a sua via, pois é um documento que traz importantes informações de contato e garante os seus direitos como participante da pesquisa. A pesquisadora responsável, que também assina esse documento, compromete-se a conduzir a pesquisa de acordo com o que preconiza a Resolução 466/12 de 12/06/2012, que trata dos preceitos éticos e da proteção aos participantes da pesquisa.

Agradecemos desde já a sua colaboração e participação.

Rafael Lima Kons
(Executor do projeto)



Daniele Detanico
(Pesquisadora responsável)

TERMO DE CONSENTIMENTO

Declaro que fui informado sobre todos os procedimentos da pesquisa e, que recebi de forma clara e objetiva todas as explicações pertinentes ao projeto e, que todos os dados a meu respeito serão sigilosos. Eu compreendo que neste estudo, as medições dos experimentos/procedimentos de tratamento serão informadas por mim e realizadas em mim.

Declaro que fui informado que posso me retirar do estudo a qualquer momento.

Nome do atleta:_____

Nome do responsável pelo atleta com deficiência visual:_____

Assinatura do atleta ou do responsável pelo atleta com deficiência visual:_____

Florianópolis, ____/____/____.

APPENDIX B - EVALUATION FORM

Dados de identificação

Nome:_____Classificação: B1 ( ) B2 ( ) B3 ( )
LogMar:_____ Data de nascimento:____/_____/_____
Data da avaliação: ____/_____/_____Prática no Judô (anos):_____
Graduação: _____ Categoria de peso: _____
Dominância: ( ) D ( ) E

Medidas antropométricas

Massa corporal (kg):		Estatura (cm):		
	1ª	*2ª*	*3ª*	*Média*
Tríceps				
Subescapular				
Supra-íliaca				
Panturrilha Média				

Special Judo Fitness Test –SJFT Situação controle						
	1ª 15s		*2ª* 30s		*3ª* 30s	
Arremessos	1	2	1	2	1	2
FC Final						
FC após 1 min						
Resultado (índice)						

Special Judo Fitness Test –SJFT Estimulo Sonoro						
	1ª 15s		*2ª* 30s		*3ª* 30s	
Arremessos	1	2	1	2	1	2
FC Final						
FC após 1 min						
Resultado (índice)						

Special Judo Fitness Test –SJFT Estimulo tátil						
	1ª 15s		*2ª* 30s		*3ª* 30s	
Arremessos	1	2	1	2	1	2
FC Final						
FC após 1 min						
Resultado (índice)						

APPENDIX C – PARECER CONSUBSTANCIADO DO CEP

UNIVERSIDADE FEDERAL DE SANTA CATARINA - UFSC

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Relação do desempenho competitivo com testes genéricos e específicos em atletas de judô das modalidades olímpica e paralímpica

Pesquisador: Daniele Detanico

Área Temática:

Versão: 2

CAAE: 63053516.4.0000.0121

Instituição Proponente: Universidade Federal de Santa Catarina

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 2.032.340

Apresentação do Projeto:

Trata-se de resposta à pendência do projeto do Programa de Pós-graduação em Educação Física do Centro de Desportos da Universidade Federal de Santa Catarina que pretende investigar a relação do desempenho técnico-tático com testes específicos e genéricos em atletas de judô de ambos os sexos que competem nas modalidades olímpica e paralímpica. Serão recrutados 50 atletas desta modalidade que pertencem a Associação

Desportiva do Instituto Estadual de Educação em Florianópolis. Os pesquisadores pretendem fazem mensurações e testes no laboratório do Centro de Desportos na UFSC e filmar competições oficias nos quais os atletas selecionados estejam envolvidos. Todos os participantes tem maioridade legal para participar do estudo voluntariamente e os que forem portadores de deficiência visual terão, ao seu lado, uma pessoa responsável que possa ajudá-lo no que se refere a compreensão do TCLE.

Objetivo da Pesquisa:

Objetivo Primário:

Investigar a relação do desempenho técnico-tático com testes específicos e genéricos em atletas de judô de

Endereço: Universidade Federal de Santa Catarina, Prédio Reitoria II, R: Desembargador Vitor Lima, nº 222, sala 401
Bairro: Trindade **CEP:** 88.040-400
UF: SC **Município:** FLORIANOPOLIS
Telefone: (48)3721-6094 **E-mail:** cep.propesq@contato.ufsc.br

UNIVERSIDADE FEDERAL DE SANTA CATARINA - UFSC

ambos os sexos que competem nas modalidades olímpica e paralímpica.
Objetivo Secundário:
- Relacionar o desempenho competitivo (efetividade, eficiência e percentual de vitórias) com o desempenho em testes genéricos e específicos do judô.- Relacionar parâmetros temporais da luta de judô com desempenho em testes genéricos e específicos.- Relacionar a variação técnica durante as lutas de judô com desempenho em testes genéricos e específicos.- Comparar o desempenho competitivo e parâmetros temporais da luta de judô,
desempenho em testes genéricos e específicos entre judocas das modalidades olímpica e paralímpica.- Comparar o desempenho competitivo e parâmetros temporais da luta de judô, desempenho em testes genéricos e específicos entre judocas de diferentes categorias e entre o sexo masculino e feminino. - Identificar os marcadores de carga interna de esforço durante as lutas competitivas (concentrações de lactato sanguíneo e percepção subjetiva de esforço) e relacioná-los com o desempenho competitivo.- Identificar as variáveis fisiológicas e neuromusculares que podem predizer o desempenho competitivo.

Avaliação dos Riscos e Benefícios:
Riscos:
1- Direito dos imagens dos atletas ficara sobre a responsabilidade dos pesquisadores
2- Mal estar ou desconforto durante as avaliações físicas
Benefícios:
Os atletas desta pesquisa estarão contribuindo de forma única para o desenvolvimento da ciência esportiva. Os resultados provenientes das analises servirão de diagnóstico de sua atual condição física e desempenho posterior em competição

Comentários e Considerações sobre a Pesquisa:
TCLE readequado e anexado na Plataforma de acordo com as orientações da Resolução 466/2012.

Considerações sobre os Termos de apresentação obrigatória:
Readequados.

Recomendações:
Inserir o nome dos pesquisadores na mesma folha onde contém o termo, na diagramação para submissão ficaram isoladas em uma página.

Conclusões ou Pendências e Lista de Inadequações:
Conclusão: aprovado.

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Continuação do Parecer: 2.032.340

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_830666.pdf	10/03/2017 12:39:54		Aceito
Outros	Resposta_parecer_cep.doc	10/03/2017 12:38:40	Rafael Lima Kons	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE_plataforma_Brasil_corrigido.docx	10/03/2017 12:37:24	Rafael Lima Kons	Aceito
Projeto Detalhado / Brochura Investigador	Projeto_cep.docx	30/11/2016 20:13:01	Rafael Lima Kons	Aceito
Outros	Termo_de_Video_e_Filmagem.pdf	30/11/2016 20:10:26	Rafael Lima Kons	Aceito
Outros	Termo_de_Anuencia.pdf	30/11/2016 20:09:38	Rafael Lima Kons	Aceito
Orçamento	Orcamento.docx	30/11/2016 20:07:06	Rafael Lima Kons	Aceito
Cronograma	Cronograma.docx	30/11/2016 16:40:08	Rafael Lima Kons	Aceito
Folha de Rosto	FolhaDerosto_assinada.pdf	30/11/2016 16:36:11	Rafael Lima Kons	Aceito

Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

FLORIANOPOLIS, 26 de Abril de 2017

Assinado por:
Ylmar Correa Neto
(Coordenador)

Endereço: Universidade Federal de Santa Catarina, Prédio Reitoria II, R. Desembargador Vitor Lima, nº 222, sala 401
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APPENDIX D - ARTICLE PUBLISHED IN ADAPTED PHYSICAL ACTIVITY QUARTERLY

Adapted Physical Activity Quarterly, (Ahead of Print)
https://doi.org/10.1123/apaq.2018-0181

Human Kinetics
ORIGINAL RESEARCH

The Effect of Vision Impairment on Competitive and Technical–Tactical Performance in Judo: Is the Present System Legitimate?

Rafael L. Kons
Federal University of Santa Catarina

Kai Krabben and David L. Mann
Vrije Universiteit Amsterdam

Gabriela Fischer and Daniele Detanico
Federal University of Santa Catarina

In judo competition for visual impairment, athletes of different classes compete against each other in the same category; B1 athletes are totally blind, whereas B2 and B3 athletes are partially sighted. To test for potential competition disparities due a single category of athletes, this study aimed to compare competitive and technical–tactical performance in visually impaired judo athletes with different degrees of visual impairment. The authors analyzed 340 judo matches from the 2012 and 2016 Paralympic Games. The scores, penalties, efficiency index, and types of medals were examined, as well as the technical variation and temporal structure. The main finding was that blind judo athletes presented lower scores ($p < .05$; effect size [ES] = 0.43–0.73), medals ($p < .05$), and efficiency ($p < .05$; ES = 0.40–0.73); different patterns of play; and a shorter time to lose than partially sighted athletes ($p = .027$; ES = 0.10–0.14). However, the penalties were similar between classes ($p > .05$; ES = 0.07–0.14). The odds ratio of a winning medal was 3.5–8 times less in blind athletes than in partially sighted athletes ($p < .01$). In conclusion, blind judo athletes presented lower competitive and technical–tactical performance than athletes with some residual functional vision. These findings provide support for the development of new evidence-based criteria for judo classification based on vision impairment.

Keywords: combat sport, Paralympic sport, technical analysis, visual impairment

Kons, Fischer, and Detanico are with the Biomechanics Laboratory and the Paralympic Sports Research Group, Sports Center, Federal University of Santa Catarina, Florianópolis, Brazil. Krabben and Mann are with the Dept. of Human Movement Sciences, Faculty of Behavioral and Movement Sciences, Amsterdam Movement Sciences, Vrije Universiteit Amsterdam, Amsterdam, the Netherlands. Kons (rafakons0310@gmail.com) is corresponding author.

APPENDIX E - ARTICLE PUBLISHED IN JOURNAL OF SPORTS SCIENCES

JOURNAL OF SPORTS SCIENCES
https://doi.org/10.1080/02640414.2021.1945776

Routledge
Taylor & Francis Group

Effect of vision impairment on match-related performance and technical variation in attacking moves in Paralympic judo

Rafael Kons[a], Kai Krabben[b], David L. Mann[b] and Daniele Detanico[a]

[a]Biomechanics Laboratory, Sports Centre, Federal University of Santa Catarina, Florianópolis, Brazil; [b]Department of Human Movement Sciences, Faculty of Behavioral and Movement Sciences, Vrije Universiteit Amsterdam, Amsterdam Movement Sciences, Amsterdam, The Netherlands

ABSTRACT

In Paralympic judo for athletes with vision impairment (VI judo) all eligible athletes (i.e. B1, B2 and B3 classes) compete against each other in the same competition. Evidence suggests that athletes with more impairment may be disadvantaged, but that more sensitive measures of performance are necessary to understand the impact of impairment on performance. The aim of this study was to investigate the relationship between Para sport class and technical variation, time-motion variables, and performance in Paralympic judo. All 175 judo matches from the Rio 2016 Paralympic Games were analysed across 129 competitors (82 male and 47 female). The main results indicated that athletes who demonstrated less technical variation also experienced less competitive success, with the functionally blind athletes (class B1) demonstrating less technical variation than partially sighted (class B2 and B3) athletes ($p < 0.05$). There was no difference in the time-motion variables between sport classes ($p > 0.05$). We conclude that measures of technical variation are sensitive to differences in impairment and are suitable for studies that investigate the impairment-performance relationship in VI judo. Results further confirm that some athletes with impairment are disadvantaged under the current rules of VI judo.

ARTICLE HISTORY
Accepted 16 June 2021

KEYWORDS
Combat sports; Paralympic judo; time-motion; variability; classification

Introduction

Movement variability has traditionally been considered a source of noise which needs to be reduced, but is more recently recognized as a key element of expertise in sports (Bartlett et al., 2007; Davids et al., 2015; Seifert et al., 2012). Successful sports performance requires an optimal mix between stability and flexibility, which enables the performer to functionally adapt to dynamic (sport) environments (Fajen et al., 2009; Van Emmerik & van Wegen, 2000) and allows creative motor actions to emerge (Orth et al., 2017). This is especially clear in interactive sports, where athletes need to co-adapt their own behaviours to that of their opponent (Hristovski et al., 2012; Pinder et al., 2011). To outperform a direct opponent (e.g., pass a defender in soccer, or strike an opponent in boxing), athletes may need to operate in metastable performance regions, where multiple competing modes of action co-exist and small perturbations can shift the dynamics of the contest either way (Duarte et al., 2012; Hristovski et al., 2006; Kimmel & Rogler,2018;K. Krabben et al., 2019b).The key implication for athletes in interactive sports is that a wider repertoire of movements will provide more options during a match and likely be associated with greater competitive success (Krabben et al., 2019b).

Judo is a highly dynamic and interactive sport which requires a variety of complex technical and tactical skills such as gripping, unbalancing, and throwing an opponent (Branco et al., 2013; Miarka, Fukuda, Del Vecchio, & Franchini, 2016). The behaviours of both athletes in a judo match are directly interdependent: action opportunities for one judo athlete continuously emerge and decay during a match depending on the behaviours of the other combatant (Gutiérrez-Santiago et al., 2011; Krabben et al., 2019b; Miarka et al., 2012). Judo athletes thus need to constantly anticipate and (re)act to their opponent (Piras et al., 2014) to successfully execute offensive and defensive actions (Courel et al., 2014). Judo athletes are encouraged to develop a range of throwing techniques to increase the unpredictability of their actions and enhance their chance of winning (Calmet & Ahmaidi, 2004; Miarka et al., 2015). Technical variation might even distinguish good from excellent elite-level judokas. Judokas who repeatedly won medals at the World or Olympic level have been found to be able to apply a greater number of different throwing techniques in matches compared to athletes who also medalled at the elite level, but who were less consistent in their performance over time (Franchini, Sterkowicz, Meira, Gomes, & Tani, 2008).

Despite the assumed benefit of technical variation in Olympic judo athletes, it remains unclear whether the relationship remains in Paralympic judo for athletes with vision impairment (VI judo), and therefore, whether technical variation is a marker of success in the sport. Although there are technical and tactical similarities between VI Judo and its Olympic counterpart, there is one key adaptation to the sport that alters the nature of competition. In VI judo, athletes must start the match with a two-handed grip on the jacket of the opponent already in place to decrease the visual demands of the sport (Gutiérrez-Santiago et al., 2011; Kons et al., 2018). This is in contrast to able-sighted judo, where athletes start the bout a few metres apart, after which they first must fight to engage and grip their opponent before they can attempt to throw him/her (Gutiérrez-Santiago et al., 2011). The adaptation in VI judo

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APPENDIX F - ARTICLE PUBLISHED IN PERCEPTUAL AND MOTOR SKILLS

Article

Perceptual and Motor Skills
0(0) 1–19

DOI: 10.1177/00315125211029009
journals.sagepub.com/home/pms
SAGE

Psychometric Suitability of Adaptations to the Special Judo Fitness Test for Athletes With Visual Impairment

Rafael L. Kons[1], Emerson Franchini[2], Jaime R. Bragança[3], and Daniele Detanico[1]

Abstract

This study aimed to test the reliability, sensitivity, construct and logical validity of an adapted Special Judo Fitness Test (SJFT) for judo athletes with visual impairment . Twenty judo athletes with visual impairments performed both the adapted SJFT with tactile and sonorous stimuli (experimental conditions) and the typically administered SJFT (standard condition). We used analyses of variance (ANOVAs) with repeated-measures to compare the groups' SJFT performances, and one-way ANOVAs to compare different visual ability classes of athletes (B1, B2 and B3). We used t-tests to compare SJFT variables between elite and sub-elite groups. We set statistical significance for all tests at $p < 0.05$. The standard SJFT showed excellent test-retest reliability for number of throws and overall index (ICC = 0.91–0.95), and both sonorous and tactile sensitivity adaptations of the SJFT showed medium sensitivity for detecting performance changes. The number of throws and SJFT index were

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