UNIVERSIDADE FEDERAL DO PARANÁ

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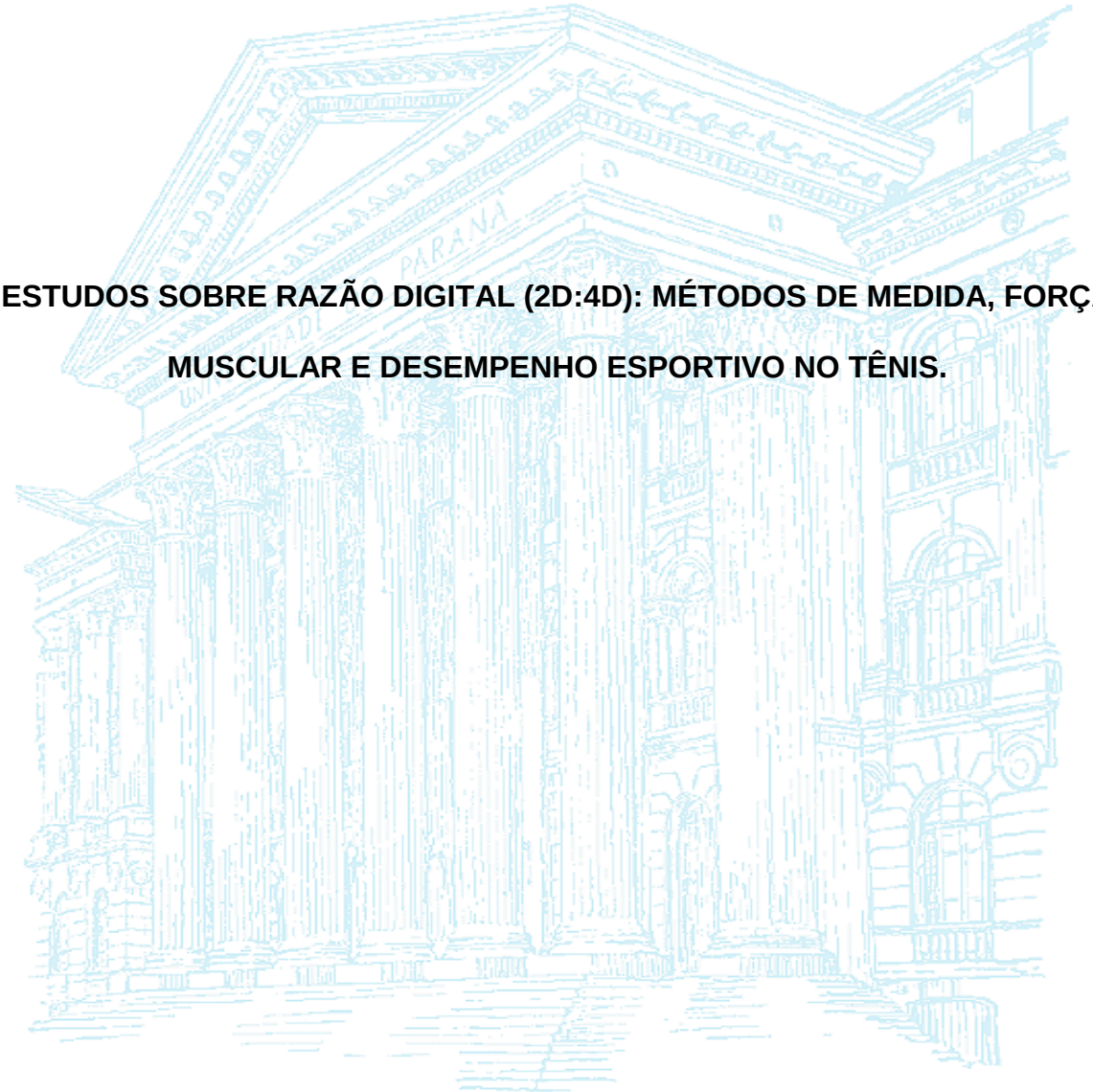

ESTUDOS SOBRE RAZÃO DIGITAL (2D:4D): MÉTODOS DE MEDIDA, FORÇA MUSCULAR E DESEMPENHO ESPORTIVO NO TÊNIS.

CURITIBA

2016

EVALDO JOSÉ FERREIRA RIBEIRO JUNIOR

ESTUDOS SOBRE RAZÃO DIGITAL (2D:4D): MÉTODOS DE MEDIDA, FORÇA MUSCULAR E DESEMPENHO ESPORTIVO NO TÊNIS.

Tese apresentada ao Programa de Pós-Graduação em Biologia Celular e Molecular na área de concentração Fisiologia, como pré-requisito para obtenção do título de Doutor em Biologia Celular e Molecular, área de concentração Fisiologia.

Orientadora: Prof. Dra. Rosana Nogueira de Morais

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Programa de Pós-graduação Biologia Celular e Molecular

Departamento de Biologia Celular
Setor de Ciências Biológicas
Universidade Federal do Paraná

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PARECER

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Após arguir o candidato ***Evaldo José Ferreira Ribeiro Junior***, em relação ao seu trabalho intitulado: "Estudos sobre razão digital (2D:4D): métodos de medida, força muscular e desempenho esportivo no tênis", são de parecer favorável à APROVAÇÃO do acadêmico, habilitando-o ao título de Doutor em Biologia Celular e Molecular.
A obtenção do título está condicionada à implementação das correções sugeridas pelos membros da banca examinadora, bem como ao cumprimento integral das exigências estabelecidas no Regimento Interno deste Programa de Pós-Graduação.

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“Stay Hungry, Stay Foolish “

(Stewart Brand - *“The Whole Earth Catalog”*, 1972, apud Steve Jobs em discurso em Stanford, 2005)

RESUMO

Durante o período embrionário a ação dos androgênios tem papel determinante na diferenciação sexual, no desenvolvimento dos órgãos sexuais masculinos e, naturalmente, produzem efeitos masculinizantes no cérebro. A baixa razão 2D:4D, obtida pela divisão do comprimento do segundo dedo (indicador) pelo quarto dedo (anelar), é apontada como indicador de androgenização pré-natal e associada com desempenho esportivo em muitas modalidades. Nós analisamos a associação da medida da razão 2D:4D com desempenho esportivo, caracteristicas fisicas, psicológicas e hormonais. Foram três estudos apresentados no formato de artigo. No estudo 1 analisanos a medida da razão 2D:4D direta (diretamente na mão do sujeito) e a medida indireta (em imagens da mão por escâner) de 114 homens e 90 mulheres e, adicionalmente, realizamos uma revisão de literatura minuciosa para comparar nossos dados. Demonstramos que há um efeito direcional no qual a medida direta da razão 2D:4D tende a ser maior que a medida indireta, ou seja, a medida indireta superestima o grau de androgenização pré-natal. No estudo 2, avaliamos, a produção de força muscular, liberação de testosterona, cortisol, agressividade e estabilidade emocional em 89 homens adultos, quando expostos a um vídeo contendo imagens de agressão no esporte (situação desafiadora) comparando com os mesmos em situação controle. Foi demostrado que a situação desafiadora modula um aumento de força muscular, de agressividade e de concentração de testosterona e ainda diminui a estabilidade emocional. A maior produção de força na situação de desafio, foi associada por regressão múltipla com baixa razão 2D:4D e a maior controle emocional. No estudo 3, avaliamos a razão 2D:4D de 64 tenistas infanto-juvenis do sexo masculino e observamos que a menor razão 2D:4D foi associada em 35% com melhor desempenho tenístico, em 20% com maior produção de força muscular, em 9% com maior potência muscular de membros inferiores e em 7% com maior índice de autoconfiança. Não encontramos associação da razão 2D:4D com concentrações hormonais, apenas confirmamos o resultado do estudo 2, no qual ocorre um aumento de testosterona em 13% quando os sujeitos foram submetidos aos desafios dos testes físicos. Por fim, indicamos que há associação da razão 2D:4D e desempenho no tênis, porém estudos em mulheres e mais aspectos necessitam ser investigados para entender melhor qual componentes explicam a relação da androgenização pré-natal e desempenho no tênis. Mesmo assim, apresentamos dados suficientes para sugerimos que a medida da razão 2D:4D pode auxiliar treinadores, como medida adicional, na avaliação física de jovens atletas.

Palavras-chave: Diferenciação sexual, Razão do dedo, 2D:4D, medida direta e indireta, força estatística, testosterona, agressão, força de preensão manual. 2D:4D.

ABSTRACT

Prenatal androgenization plays an important role in human brain development and influences human behaviour. Digit ratio (2D:4D), the relative lengths of the index finger (2D) and the ring finger (4D), is a putative marker for prenatal testosterone and is correlated with performance in many sports. This thesis analysed the relationship between 2D:4D ratio with sport performance and physical, psychological and endocrine characteristics. It divided in three studies, and in the first one we investigated a methodological question regarding 2D:4D measuring. We compared direct versus indirect measurement of digit ratio (114 males and 90 females). And reviewed the literature on this issue. We found that direct 2D:4D measuring tends to be larger than indirect ones, indicating that direct and indirect mean 2D:4D's should not be compared in between-population studies. On the second study, we hypothesised that correlation between 2D:4D and strength may be strongest in challenge conditions when short-term changes occur in steroid hormones. The challenge condition increased Handgrip strength (HGS), and elicited modest changes in testosterone (T), physical aggression and emotional stability. HGS correlated negatively with left hand 2D:4D. In a multiple regression, left hand 2D:4D was negatively related to HGS and emotional stability was positively related to HGS. In the control condition HGS was not correlated with 2D:4D. Our conclusions were that 2D:4D is a negative correlate of strength in challenge situations and this finding may in part explain associations between 2D:4D and sports performance. In the third study, we assessed 64 male junior tennis players and found that low 2D:4D ratios were associated in 35% with better tennis performance, in 20% with higher HGS, in 9% with explosive muscular strength and in 7% with best self-confidence. There was no relationship between 2D:4D ratios and steroid hormones, although, as we found on study two there was a T increase in 13% after the physical tests challenge. Finally, we suggest that there are associations with 2D:4D ratios and junior tennis performance, however, studies in female junior tennis players and other sports-related variables are still needed. We suggest that 2D:4D ratios could help sports coaches as an additional measure on young athlete assessments.

Key words: Sexual Differentiation, Digit Ratio, 2D:4D; direct vs indirect measurement; Tennis; Testosterone; Aggression; Hand-grip Strength

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CAPITULO 1 - APRESENTAÇÃO

1.1 Estrutura da tese e procedimentos

1.2 Introdução geral

1.3 Objetivo geral

1.1 Estrutura da Tese e procedimentos

Esta tese está estruturada em seis capítulos (TABELA 1). Este modelo de tese vem sendo chamado de “coletânea de estudos” e, apesar de ainda não haver normatização específica, já é muito utilizado e aceito nos programas de pós-graduação. Após uma breve introdução do tema (Capítulo 1), apresento uma revisão de literatura no Capítulo 2. Nos capítulos seguintes, são apresentados os estudos que compõem a tese, no formato de artigo conforme já publicados nos respectivos periódicos (Capítulos 3 e 4) ou nas normas e idioma do periódico a ser submetido (Capítulo 5). Finalmente apresento as principais conclusões da tese com base nos estudos realizados e algumas considerações finais. A lista de referências bibliográficas, ao final da tese, não contempla as utilizadas nos artigos, uma vez que aparecem ao final de cada artigo.

TABELA 1 - ESTRUTURA DA TESE

Capitulo 1	**Introdução Geral** Apresentação geral do tema estudado e objetivos da tese
Capitulo 2	**Revisão da literatura** Exposição aprofundada em temas abordados introdutoriamente no capitulo 1
Capitulo 3	**Artigo 1 -** Direct vs Indirect Measurement of Digit Ratio (2D:4D): A Critical Review of the Literature and New Data Publicado no periódico: Evolutionary Psychology, FI = 1.389
Capitulo 4	**Artigo 2 -** Digit ratio (2D:4D), testosterone, cortisol, aggression, personality and hand-grip strength: Evidence for prenatal effects on strength. Publicado no periódico: Early Human Development, FI = 1.785
Capitulo 5	**Artigo 3 -** Digit ratio (2D:4D) predicts performance in junior tennis players Em construção para o periódico “Journal of Sports Sciences”, FI = 2.142
Capitulo 6	**Conclusões e considerações**

Para a realização da tese, foram adotados procedimentos diferentes entre os estudos, uma vez que foram consideradas populações distintas. Os dois primeiros estudos foram realizados no Reino Unido, durante o período de doze meses de estágio sanduiche. Para estes, foi obtido aprovação no comitê de ética do departamento de psicologia da “Northumbria Universty” em acordo com “School of Life Sciences Ethics Committee”. Para o primeiro estudo, que comparou medida da razão 2D:4D direta e indireta, foram recrutados participantes voluntários de ambos os sexos em bibliotecas e diversos locais da “Northumbria Universty” na cidade de Newcastle Upon Tyne, Inglaterra, conforme os métodos descritos no artigo do Capítulo 3. Para o segundo estudo foram recrutados apenas homens, entre 18 e 35 anos, na cidade de Newcastle na Inglaterra e Wrexham no País de Gales, os quais foram submetidos a um experimento que consistia em duas visitas ao laboratório. Antes de ser submetido ao experimento, o voluntário lia o termo de esclarecimento (Anexo 1) e assinava os termos de consentimento (Anexo 2), os demais detalhes metodológicos são descritos no estudo do Capítulo 4.

Para o terceiro estudo, realizado no Brasil, foi obtido aprovação no comitê de ética em pesquisa com seres humanos da Universidade Federal do Paraná - CEP/SD (parecer de aprovação do projeto no Anexo 3). Neste estudo, que envolveu crianças e adolescentes (11 a 17 anos), os responsáveis dos participantes assinaram o “Termo de Consentimento Livre e Esclarecido” (anexo 4) e os tenistas assinaram o “Termo de Assentimento”, termo destinado a crianças e adolescentes (Anexo 5). Neste estudo, os tenistas foram avaliados no seu local de treino, antes de uma seção normal de treinamento e a descrição metodológica consta no estudo do Capítulo 5.

1.2 Introdução Geral

Homens e mulheres diferem em muitos aspectos, incluindo aparência, força, capacidades físicas, habilidades motoras e rítmicas, identidade social, parceiros sociais, atividades de interesse, aspirações, valores, bem como a probabilidade e especificidade na manifestação de problemas psicológicos e físicos (Collaer & Hines, 1995). Estas diferenças são multifatoriais (genéticas, fisiológicas e sociais), nas quais, os hormônios sexuais, presentes durante períodos sensíveis do desenvolvimento, desempenham papéis determinantes (Berenbaum & Beltz, 2011).

Durante o período intrauterino, o cérebro humano se desenvolve na direção do sexo masculino por meio da ação direta da testosterona gonadal do feto masculino, e na direção do sexo feminino pela ausência desse hormônio. A ação dos hormônios sexuais sobre as células nervosas em desenvolvimento, implica em mudanças organizacionais permanentes, gerando circuitos sinápticos cerebrais. Neste período, diferenças sexuais em relação à cognição e a comportamentos (como agressividade, por exemplo) são programados (Melissa Hines, 2006; Swaab, 2007).

Para se testar a ação dos hormônios sexuais sobre o comportamento humano, são necessários indicadores fisiológicos e/ou antropométricos que possam avaliar, de modo indireto e retrospectivo, o nível de androgenização pré-natal, já que a determinação direta, como é feita em animais por meio de manipulação dos níveis hormonais, possui uma série de limitações metodológicas e éticas. Um desses indicadores de androgenização pré-natal é a razão 2D:4D, a qual é obtida pela divisão do comprimento do segundo dedo (indicador) pelo quarto dedo (anelar).

A razão 2D:4D é conhecida há mais de 100 anos (Baker, 1888) e apresenta valores maiores em mulheres do que em homens (PHELPS, 1952). Apenas em 1998, foi aventada a hipótese de que a razão 2D:4D poderia estar relacionada ao balanço de testosterona (T) e estrogênio (E), ao qual o feto é exposto na vida intrauterina (J T Manning, Scutt, Wilson, & Lewis-Jones, 1998). Com isso, também se postulou que, assim como a razão 2D:4D é diferente entre homens e mulheres, as diferenças da razão 2D:4D entre o mesmo sexo, também podem estimar as diferentes exposições ao balanço de estrogênios e androgênios pré-natais. Esta

hipótese estimulou pesquisadores em todo mundo a estudarem a razão 2D:4D. A quantidade de artigos publicados anualmente aumentou de 1 (em 1998) para 51 (em 2007) e, entre 2008 a 2010 eram publicados em média, cerca de 61 artigos por ano (J. T. Manning, 2011).

Em meio ao grande número de estudos, demonstrou-se correlação entre a razão 2D:4D e a eficiência da proteína receptora de androgênio (AR) (Breedlove, 2010) e observou-se que a razão 2D:4D é uma medida estável, a partir da 14ª semana de gestação (Galis, Ten Broek, Van Dongen, & Wijnaendts, 2010). Crianças ente 8 e 11 anos de idade já apresentam médias da razão 2D:4D muito similares a de estudos com população adulta (Ranson, Stratton, & Taylor, 2015). Zheng e Cohn (2011) demostraram um elevado número de receptores androgênicos e a presença de 19 genes sensíveis a testosterona e estrogênio presentes nos ossos das falanges do quarto dedo (anelar) durante sua formação, o que explica por que a razão 2D:4D sofre alteração, quando exposto a diferentes concentrações pré-natais de testosterona e estrogênio.

Porém, no alto número de publicações encontra-se também muitas falhas em replicações de estudos (Bang et al., 2005; Dressler & Voracek, 2011; Firman, Simmons, Cummins, & Matson, 2003; Folland, Mc Cauley, Phypers, Hanson, & Mastana, 2012). Estas discordâncias podem residir principalmente em falhas metodológicas. Por exemplo, um viés metodológico no qual medidas indiretas (por fotocopias ou escâner) tendem a apresentar menores razão 2D:4D que por medidas diretas (John T Manning, Fink, Neave, & Caswell, 2005; E. Ribeiro, Neave, Morais, & Manning, 2016).

Os efeitos androgênicos estão associados a vantagens em desempenho esportivo e capacidades físicas na vida adulta (John T Manning & Taylor, 2001). Estas, vantagens são evidentes em muitos esportes, tarefas competitivas e até mesmo tarefas cotidianas que necessitam de tais capacidades, como habilidade numérica e espacial (Bull & Benson, 2006). Em estudo de meta análise, Hönekopp e Schuster (2010) analisaram 21 estudos, incluindo vários esportes, totalizando 2527 sujeitos e concluíram que medidas de capacidade atlética são negativamente relacionadas à razão 2D:4D em ambas as mãos e ambos os sexos, com média de correlação (r) de – 0,26 e valores de R^2 variando de 2% a 30%. Tendo em vista a força dessas associações, parece ser pouco provável que a ligação entre a androgenização pré-natal e desempenho esportivo se explique apenas por traços

comportamentais (Hill, Simpson, Millet, Manning, & Kilduff, 2012). Apesar de a razão 2D:4D estar associada a alguns traços de personalidade que podem ser úteis no esporte, como agressividade (Hönekopp & Watson, 2011), as associações entre personalidade e razão 2D:4D são fracas e não suscetíveis de se associar com desempenho esportivo (Tester & Campbell, 2007). Por essa razão, componentes do desempenho esportivo como força, potência muscular, assim como, componentes psicológicos, precisam ser mais explorados, para que se compreenda melhor quais deles são influenciados pela androgenização pré-natal.

Assim, escolhemos a modalidade de tênis como objeto de estudo desta tese, para melhor explorar estes componentes supracitados. No tênis, o desempenho está fortemente associado à capacidade de força, potência muscular e capacidades psicológicas (Brouwers, De Bosscher, & Sotiriadou, 2012; Fernandez-Fernandez, Mendez-Villanueva, Fernandez-Garcia, & Terrados, 2007; Fernandez, Mendez-Villanueva, & Pluim, 2006; Hoppe et al., 2014; Kovacs, 2007). Além disso, ao contrário de esportes coletivos, no tênis há uma facilidade metodológica para associações de desempenho com parâmetros hormonais, físicos e psicológicos, por ser um esporte individual. Até o momento, apenas um único estudo, realizado em Taiwan, analisou a razão 2D:4D em tenistas (Hsu et al., 2015), demostrando que tenistas de elite possuem menores índices de razão 2D:4D (0.966 ± 0.010) do que tenistas de nível universitário (0.978 ± 0.005) e estes, por sua vez, apresentam razão 2D:4D menores que não atletas (0,986 ± 0,003; N=166). Este estudo faz associações apenas da razão 2D:4D e nível de excelência alcançado, comparando grupos com o pressuposto de que estes grupos possuem diferentes níveis de desempenho, porém não associa a razão 2D:4D com desempenho individual e não avalia quais componentes do desempenho, influenciados pela androgenização pré-natal, contribuem ao nível de excelência alcançado. Assim, considerando as características do tênis e a escassez de estudos da razão 2D:4D nesta modalidade, justifica-se a investigação da associação entre razão 2D:4D, desempenho tenístico e alguns componentes do desempenho, como força, potência muscular e componentes psicológicos.

1.3 Objetivos

- Comparar a medida direta e indireta (por escâner ou fotocópia) e discutir sobre um possível efeito direcional no qual a medida direta da razão 2D:4D tende a ser maior do que a medida indireta.
- Avaliar a produção de força muscular, liberação de testosterona, cortisol e aumento de agressividade de homens expostos a um vídeo contendo imagens de agressão no esporte (situação desafiadora) comparando com os mesmos em situação controle.
- Avaliar a razão 2D:4D de tenistas infanto-juvenis e associar com o desempenho tenístico, força muscular, potência muscular de membros inferiores e resistência mental.

CAPITULO 2- REVISÃO DE LITERATURA

2.1 O processo de diferenciação sexual e diferenciação cerebral

2.2 Dimorfismos sexuais e a razão 2D:4D

2.3 A razão 2D:4D e desempenho esportivo

2.1 Diferenciação sexual e cerebral

Classicamente o evento pivô da diferenciação sexual é a especialização das gônadas primordiais em ovário ou testículo, sendo as demais diferenças entre os sexos efeitos secundários decorrentes dos hormônios produzidos pelas gônadas. O desenvolvimento e diferenciação das gônadas inicia-se na sexta semana de gestação, sob a influência de uma cascata de genes, tal como o gene determinante do sexo (SRY), presente no cromossomo Y. A produção de androgênios pelo testículo do feto masculino é essencial para a diferenciação dos órgãos sexuais, estimulando o desenvolvimento do sistema wolffiano (epidídimo, canal deferente e vesículas seminais) e o desenvolvimento da genitália externa. Já o desenvolvimento intrauterino dos órgãos sexuais femininos é baseado principalmente na ausência de androgênios e suas ações (Gubbay et al., 1990; McCarthy, 2008; M. P. de Melo, Assumpção, & Hackel, 2005). Para revisão detalhada ver Capel, (2000), Brennan e Capel, (2004), Kocer et al. (2009).

O início da formação dos testículos é marcado pelo aparecimento das células de Sertoli, as quais organizarão a formação dos túbulos seminíferos, envolvendo as células germinativas. As células de Sertoli são importantes para a produção do hormônio Anti-Mulleriano (AMH) ou também chamado de substância inibidora de Muller (MIS), o qual é necessário para inibir o desenvolvimento dos ductos de Muller (Magre & Jost, 1984). O segundo estágio da diferenciação dos testículos é o aparecimento das células de Leydig fetais. Estas promoverão a síntese e secreção de testosterona, sendo reguladas, inicialmente, pela gonadotrofina coriônica (hCG) e, posteriormente, pela gonadotrofina hipofisária fetal, o LH hipofisário fetal. A falha no estímulo pelo hCG ou LH resulta em deficiência da produção de testosterona e de seu metabólito ativo, a dihidrotestosterona e, consequentemente, na falência de virilização da genitália externa na vida intrauterina, em indivíduos geneticamente masculinos (ver revisões de LATRONICO et al., 2005 e SHARPE, 2006). O terceiro estágio na determinação do testículo é a diferenciação e desenvolvimento das células germinativas primordiais em espermatogônias.

A formação dos ovários ocorre na ausência de AMH e de hormônios androgênicos, propiciando o desenvolvimento do sistema, ainda indiferenciado, em ovários e estruturas tubulares derivadas dos ductos de Muller, dando origem aos ovidutos e útero. A partir das células germinativas primordiais formam-se os oócitos e, em seguida, com a diferenciação das células somáticas ao redor dos oócitos, formam-se os folículos primordiais (etapa inicial da foliculogênese). Quanto aos hormônios femininos, sabe-se que os estrogênios (C^{18} estrogênio) são formados a partir de androgênios (C^{19} androgênio), sob ação da enzima aromatase (CYP-19). Esta enzima é detectada em tecidos fetais e na placenta, indicando que a aromatização de androgênios para estrogênios é absolutamente factível no ambiente embrionário. A aromatase presente na placenta materna previne que a testosterona materna se difunda ao feto e que a testosterona fetal, se houver, virilize a mãe. Como consequência da diferenciação gonadal e endócrina do feto, simultaneamente, ocorre também a diferenciação da genitália externa, definindo-se, então as características sexuais primárias. Para ambos os sexos, uma vez que a diferenciação dos órgãos sexuais já esteja estabelecida, a próxima etapa é a diferenciação sexual secundária, que é a resposta de vários tecidos aos hormônios produzidos pelas gônadas para complementar o fenótipo sexual. A diferenciação do cérebro é um exemplo, o qual com a ação dos hormônios sexuais sobre as células nervosas em desenvolvimento, sofrerá mudanças organizacionais permanentes, gerando circuitos sinápticos cerebrais e comportamentos distintos entre os sexos (Jazin & Cahill, 2010).

Durante o desenvolvimento intrauterino, a testosterona vai definir também o desenvolvimento do cérebro no sentido masculino ou feminino (ver revisão de SWAAB, 2007). A diferenciação sexual gonadal ocorre durante os dois primeiros meses de gestação, ou seja, muito antes da diferenciação cerebral, a qual ocorre apenas na segunda metade da gestação. Estes dois processos podem ser influenciados de modo independente um do outro, o que pode resultar no fenômeno da transexualidade (pessoas com órgãos sexuais masculinos sentindo-se como mulher e vice-versa).

A testosterona desempenha um papel importante no desenvolvimento e ativação do cérebro em mamíferos. Este papel é classificado em efeitos “organizacionais” ou “ativadores”. Os organizacionais ocorrem quando a

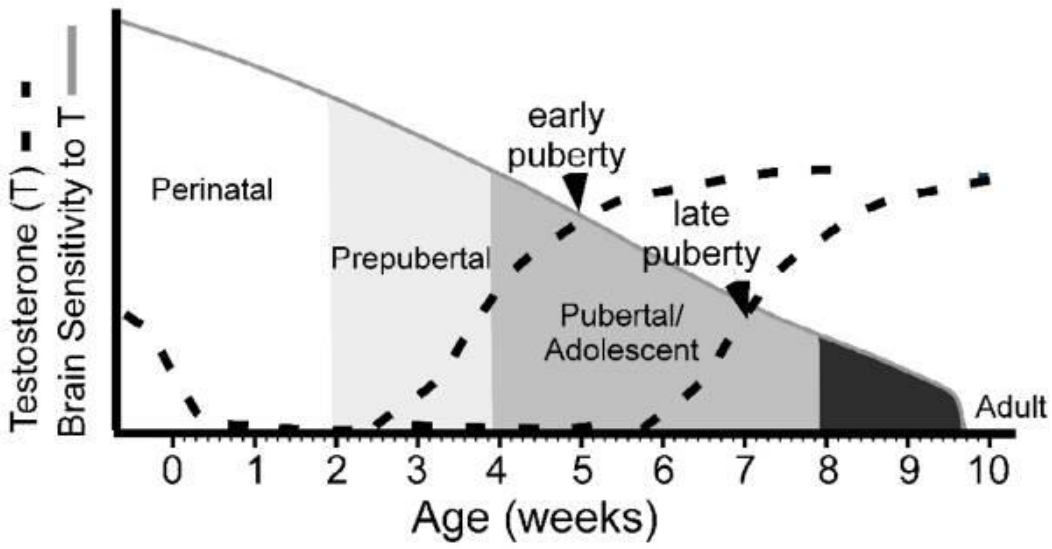
testosterona produz mudanças estruturais permanentes no cérebro, principalmente em períodos sensíveis pré-natais, enquanto os “ativadores”, ocorrem mais tardiamente, produzindo mudanças temporárias nas estruturas cerebrais e no comportamento como, por exemplo, as mudanças comportamentais que ocorrem na transição de crianças para adolescentes e adultos. Embora essas distinções não sejam absolutas, as principais distinções entre efeitos “organizacionais” e “ativadores” dizem respeito ao tempo em que ocorrem e à permanência ou não dos mesmos (Arnold & Breedlove, 1985).

Existem períodos críticos do início da vida nos quais os níveis hormonais exercem maior influência nos efeitos “organizacionais” no cérebro. Estes períodos variam de espécie para espécie, sendo que em ratos o período crítico ocorre entre o 1º e o 19º dia após o nascimento, enquanto que em macacos “*Rhesus*” este período ocorre antes do nascimento. Em humanos, o aumento de testosterona no feto masculino inicia-se entre a 12ª até a 18ª semana de gravidez e o pico está por volta da 16ª semana (Finegan, Bartleman, & Wong, 1989). Há um outro pico de testosterona sérica após o nascimento, no qual os meninos podem chegar a apresentar níveis dez vezes maiores que meninas (Zegher, Devlieger, & Veldhuis, 1992). Segundo Auyeung et al. (2013), o período crítico dos efeitos “organizacionais” em humanos, coincide com o período de pico de liberação de testosterona.

Os períodos pré-natais e perinatais são aceitos como os principais períodos de sensibilidade cerebral aos hormônios, porém, estudos em modelos animais, demonstram evidências de que efeitos “organizacionais” e “ativadores” sobre o comportamento também são possíveis durante a adolescência. Adicionalmente, uma puberdade adiantada pode representar maior impacto nas estruturas cerebrais e comportamentos quando comparada com uma puberdade tardia. Isto se deve pela relação entre liberação de testosterona e sensibilidade cerebral. Note na FIGURA 1 que, ao longo do tempo, há uma diminuição da sensibilidade cerebral às ações organizadoras de testosterona. Devido a isso, quanto antes for o início da puberdade, maior será o efeito dos esteroides sexuais no desenvolvimento do cérebro e no comportamento adulto. As linhas tracejadas descrevem as secreções precoce ou tardia de testosterona ao longo do desenvolvimento, enquanto a linha contínua descreve a sensibilidade decrescente para as ações organizadoras da

testosterona em todo o desenvolvimento. As áreas sombreadas indicam as fases dos períodos perinatal, pré-pubertal e a adolescência no hamster sírio. (Schulz, Molenda-Figueira, & Sisk, 2009).

FIGURA 1: ILUSTRAÇÃO TEÓRICA DA RELAÇÃO ENTRE LIBERAÇÃO DE TESTOSTERONA E SENSIBILIDADE CEREBRAL NO HAMSTER SÍRIO



FONTE: (Schulz et al., 2009)

Phoenix et al. (1959), demonstraram efeitos “organizacionais” e “ativadores” sobre o cérebro, administrando testosterona no período pré-natal e perinatal em cobaias. Este estudo pioneiro motivou, ao final da década de 60 até meados da década de 80, uma extensa fonte de evidências empíricas com experimentos realizados em mamíferos (roedores e primatas não humanos). Foram demonstradas influências hormonais em padrões de morte ou sobrevivência celular, conectividade e caracterização neuroquímica de células neurais (ver revisão de WILSON; DAVIES, 2007).

Em relação ao comportamento, os estudos demonstram que a administração de testosterona pré-natal estimula comportamentos não reprodutivos e reprodutivos característicos. Por exemplo, em ratas, uma simples injeção de testosterona no período perinatal, estimulou o aumento da aprendizagem espacial e maior exploração de campo aberto, maiores ocorrências de brincadeiras agressivas e quedas, comportamento típicos masculinos nessa espécie. No macaco rhesus

fêmea, o aumento de testosterona também aumentou brincadeiras agressivas, típicas masculinas, houve maior aprendizagem e discriminação visual. Já comportamentos contrários, tipicamente femininos, também foram observados em machos pela supressão de testosterona como, por exemplo, castração ou administração de desregulados endócrinos. Quanto a mudanças de comportamentos sexuais, a administração de testosterona induziu nas fêmeas posturas de acasalamento sexual típicas de machos (monta). Também foram verificadas diferenças entre indivíduos de mesmo sexo quando expostos a diferentes concentrações de testosterona. Por exemplo, as variações pré-natais nos níveis hormonais em ratos como resultado do estresse materno ou por proximidade intrauterina entre fêmeas e machos, determinam diferenças no comportamento sexual, no jogo juvenil e na capacidade de aprendizagem no "labirinto" (Collaer & Hines, 1995; Melissa Hines, 2006)

Em humanos, pelas razões éticas já comentadas, os estudos da relação entre variações da androgenização e comportamento se concentraram em duas abordagens metodológicas principais: 1) estudar indivíduos com distúrbios genéticos causadores de anormalidades na quantidade e/ou atividade da testosterona, desde a fase pré-natal ou, 2) estudar indivíduos cujas mães tenham sido, por prescrição médica, tratadas com hormônios durante a gestação. Uma terceira estratégia, foi estudar indivíduos sem história de anormalidade hormonal, porém com informações sobre os níveis hormonais pré-natais disponíveis (Melissa Hines, 2006).

Vários estudos desta natureza, em humanos, avaliou meninas ou mulheres com hiperplasia adrenal congênita (CAH). A CAH, é uma doença autossômica recessiva que leva à deficiência na enzima adrenal P450, a qual faz a mediação da atividade da 21-hidroxilase. Esta doença afeta 1 em cada 1450 nascimentos mundialmente e, por gerar elevados níveis de testosterona pré-natais, têm efeitos masculinizantes em meninas, ao passo que o feto masculino praticamente não é afetado (Speiser & White, 2003). Esta virilização, se não tratada, continua após o nascimento e pode causar rápido crescimento ósseo, aumento de massa muscular, acne, aparecimento prematuro de pelos pubianos e axilares. Quanto ao comportamento, as meninas com CAH, apresentam preferências por brincadeiras e brinquedos tipicamente masculinos (ex. brincar de lutas, derrubar – "*rough and tumble play"*, armas e automóveis"). Também demonstrou-se que meninas com CAH

têm preferência por brincar com meninos, ao contrário da normalidade, que em 80 a 90% dos casos preferem brincar com parceiras do mesmo sexo (M Hines & Kaufman, 1994). Mulheres adultas com CAH, são menos propensas a ser exclusivamente heterossexuais, quando comparadas a suas irmãs não afetadas, a controles correspondentes à idade e ao contexto demográfico, ou ainda se comparadas a mulheres com outras perturbações que causam anormalidades hormonais ou dos órgãos genitais externos (Dittmann, Kappes, & Kappes, 1992; Money et al., 1984).

Estudos realizados em pacientes com síndrome de insensibilidade androgênica (AIS) fornecem suporte adicional ao papel da testosterona pré-natal e desenvolvimento psicossocial. Esta doença genética caracteriza-se pelo fato de os receptores de androgênios não responderem, parcialmente (AIS parcial) ou completamente (CAIS), à ligação de androgênios, resultando em falha da masculinização em fetos do sexo cromossômico masculino. Nesta síndrome é possível evidenciar indivíduos 46, XY com CAIS desenvolverem genitália, aparência e comportamentos completamente femininos (Melissa Hines, Ahmed, & Hughes, 2003). Melo et al. (2003) descreveram características físicas e psicológicas de uma amostra de vinte e dois pacientes AIS brasileiros. Destes, vinte pacientes possuíam CAIS e cresceram como meninas, mantendo seu gênero feminino na vida adulta, enquanto os outros cinco pacientes eram AIS parciais, mas também cresceram como garotas e, apesar de certo grau de virilização genital, mantiveram o status feminino na vida adulta.

Os estudos das relações entre a variabilidade normal dos níveis maternos da testosterona durante a gestação e o comportamento pós-natal em indivíduos sem história de anormalidade hormonal são um verdadeiro desafio. As diferenças entre um feto saudável e outro, em níveis hormonais, são muito pequenas, e consequentemente as diferenças comportamentais são pequenas também, a ponto de, dependendo do instrumento ou método, as diferenças serem aparentemente nulas. Hines (2006) acredita que grande parte das falhas ao tentar estabelecer as relações TP e comportamento, por estimativa a partir da testosterona materna no período gestacional, falham por problemas metodológicos, como um baixo número de sujeitos ou instrumentos e medidas inadequados.

Primeiramente, para entender esta abordagem metodológica, é necessário saber que há correlação significativa entre a testosterona do feto e a testosterona materna. Em meninos essa correlação é cerca de 61% e, em meninas, cerca de 44% (Gitau, Adams, Fisk, & Glover, 2005). Outro fato é que a produção de testosterona é altamente hereditária. Foi atribuído cerca de 60% de hereditabilidade para homens e 40% para mulheres (Harris, Vernon, & Boomsma, 1998; Sluyter et al., 2000). Portanto, durante a gravidez, a testosterona materna estima, de forma indireta, a testosterona fetal, acreditando-se que as testosteronas fetais e maternas compartilham mecanismos de controle comuns durante a gestação. Usando esta abordagem, um estudo demonstrou que a testosterona materna, avaliada durante o segundo trimestre de gravidez, previa comportamentos masculinizados em mulheres adultas entre 27-30 anos (Udry, Morris, & Kovenock, 1995). Outro estudo, demonstrou que a testosterona materna durante a gravidez, previu, em meninas em idade pré-escolar (3,5 anos), interesses típicos masculinos, ao passo que, no mesmo estudo, não foi encontrada esta associação em meninos (Melissa Hines, Golombok, Rust, Johnston, & Golding, 2002).

2.2 Dimorfismos sexuais e a razão 2D:4D

Diferenças morfológicas entre homens e mulheres, conhecidos como dimorfismos sexuais, são atribuídos à influência hormonal em períodos sensíveis pré-natais. Podem ser incluídos dentre esses dimorfismos, por exemplo, o formato da face, a distância anogenital e também a razão entre os comprimentos do segundo e quarto dígitos (razão 2D:4D), os quais têm sido utilizados, como indicadores retrospectivos dos níveis de TP.

Muitos dimorfismos sexuais se tornam evidentes durante a puberdade, como por exemplo as diferenças em peso, estatura, tamanho da mandíbula, espessura das sobrancelhas, circunferência da cintura, quadril e largura dos ombros. Apesar do desenvolvimento dos seios ser uma característica típica das mulheres, o desenvolvimento pré-natal dessa região média torácica é idêntico em meninos e meninas desde o início do desenvolvimento embrionário. Ao nascimento, 80% de ambos (meninos e meninas) produzem leite. Até a puberdade não há muitas

mudanças, sendo que cerca de 38% dos meninos no início da puberdade ainda apresentam certa ginecomastia, a qual será resolvida em 98% dos casos até os 16 anos. Nas meninas, a mudança considerável nessa região torácica ocorre somente na puberdade, a partir do estímulo estrogênico apropriado, ocasionando o crescimento dos seios. Um padrão similar de dimorfismo sexual, pode ser observado no esqueleto da mandíbula, as diferenças são perceptíveis apenas a partir da puberdade e mais evidentes entre os vinte e os cinquenta e cinco anos.

Poucos dimorfismos sexuais são evidentes antes da puberdade ou mesmo em estágios fetais. Por exemplo, em crianças recém-nascidas, a entrada pélvica é mais circular nas mulheres, enquanto que no sexo masculino tem mais a forma de coração, por conta da posição do sacro. O sacro é mais largo em mulheres, com uma curva superficial, enquanto a curva nos homens, é mais continua e o cóccix pode ser projetado para frente. Estas diferentes formas pélvicas entre os sexos são resultado de ações hormonais e se tornarão mais evidentes na puberdade. Baseados nas conhecidas diferenças ósseas dessa região pélvica, muitos estudos interessados em estudar o ambiente androgênico intrauterino adotam a medida de distância anogenital (AGD), a qual pode ser cerca de duas vezes maior em ratos machos do que em fêmeas (Welsh et al., 2008).

São encontrados na literatura muitos estudos utilizando AGD em diversos animais (Hsieh, Breyer, Eisenberg, & Baskin, 2008), incluindo os humanos (A. Thankamony, Pasterski, Ong, Acerini, & Hughes, 2016). Estes estudos descrevem principalmente associações entre o dimorfismo AGD (que representa os efeitos dos androgênios pré-natal) com desreguladores endócrinos e anomalias genitais. A exemplo, menor AGD no sexo masculino está associada a uma exposição androgênica deficiente nos períodos sensíveis pré-natais e, paralelamente, associados a tamanho reduzido de testículos, próstata, vesícula seminal e pênis, assim como risco aumentado de hipospadia, criptorquidismo, baixa produção de espermatozóides e baixos níveis de testosterona (DRAKE et al., 2009; THANKAMONY et al., 2014).

Outro dimorfismo sexual perceptível desde o desenvolvimento intrauterino é a razão 2D:4D. Esta medida, principalmente pela facilidade da sua medida, tem sido considerada uma boa oportunidade de explorar, retrospectivamente, os efeitos de concentrações de esteroides pré-natais. Porém, o que justifica a ligação dos dedos e

concentrações pré-natais de esteróides? Esta compreensão inicia-se na formação dos ossos dos dedos desde o desenvolvimento embriológico.

O padrão geral do desenvolvimento em animais multicelulares é controlado pelo Homeobox (ou HOX genes). Em humanos são 39 HOX genes organizados em quatro clusters designados: *HOXa, HOXb, HOXc e HOXd* (Scott, 1997). Estes clusters contêm cerca de 9 a 11 genes cada e estão localizados respectivamente nos cromossomos 7p14, 17q21, 12q13 e 2q31. Dois grupos de genes *HOXa* e *HOXb* controlam ambos o desenvolvimento da genitália e o desenvolvimento dos dedos das mãos e pés (Kondo, Zákány, Innis, & Duboule, 1997; Douglas P Mortlock, Post, & Innis, 1996). Em seres humanos, mutações do HOXa, em particular do *HOXa 13*, podem resultar na síndrome HFG ("*hand foot genital syndrome*"), com defeitos nos dedos e sistema urogenital (Imagawa et al., 2014; D P Mortlock & Innis, 1997). Nos membros, estes defeitos incluem tamanho encurtado do primeiro metacarpo, dedos polegares com falanges distais reduzidas, anormalidades do segundo e quinto dedos, fusão dos ossos do pulso e tamanho reduzido do dedo médio (terceiro dedo). No sistema urogenital, a uretra pode apresentar uma divisão parcial ou completa e abertura deslocada da uretra. Similarmente, estudos em roedores sugerem alterações de dedos e sistema urogenital a partir da desregulação do HOXd (Hérault, Fraudeau, Zákány, & Duboule, 1997; Peichel, Prabhakaran, & Vogt, 1997). Em humanos, essa desregulação pode causar a condição de sindactilia entre o terceiro e quarto dedo, uma anormalidade embriológica que resulta na visível união entre dois ou mais dedos das mãos ou dos pés, em diferentes graus, desde fusão apenas cutânea até fusão óssea.

O HOX gene foi descoberto em drosófilas há 30 anos e estudos subsequentes demostraram a evolução dos HOX genes (origem, conservação funcional, propriedades regulatórias), o papel dos mesmos nos vertebrados (detalhes na revisão de HRYCAJ; WELLIK, 2016), desordens do HOX genes e malformações em humanos (Goodman & Scambler, 2001; Quinonez & Innis, 2014), bem como descrições moleculares e mecanismos de ação (Beccari et al., 2016; Ros, 2016; Utsch et al., 2007). Há também descrições da regulação endócrina dos HOX genes (Daftary & Taylor, 2006; Huang, Pu, Hepps, Danielpour, & Prins, 2007), assim como descrições da regulação, transcrição e expressão fenotípica nos dedos (Martínez-Abadías, Mateu, Niksic, Russo, & Sharpe, 2016; Montavon et al., 2011;

Pezzani et al., 2015). Assim, existem descrições suficientes para se acreditar que a formação dos dedos e genitália compartilham uma mesma origem de desenvolvimento embriológico, de modo que, qualquer disfunção que afete uma tenha o potencial para afetar também a outra. No entanto, surge um outro questionamento que é o porquê de os androgênios afetarem de forma seletiva a razão 2D:4D ao invés de outros aspectos ósseos dos dedos ou da mão.

A razão 2D:4D e seu dimorfismo entre o sexo masculino e feminino, são conhecidos há mais de 100 anos e trata-se, como já citado, da relação do comprimento do segundo dedo (indicador) com o quarto dedo (anelar) (Baker, 1888). Homens tendem a apresentar o quarto dedo mais comprido que o segundo dedo, enquanto que mulheres tendem a ter comprimento igual dos dois dedos ou o segundo dedo maior do que o quarto, embora ambos os sexos possam apresentar todos os três padrões 2º>4º, 2º=4º, 2º<4º. (George, 1930; PHELPS, 1952). Muitos estudos, historicamente, demonstraram as diferenças entre sexos, na qual homens apresentam menores valores na razão 2D:4D que mulheres (ver revisão de PETERS et al., 2002). Nesta revisão, os autores dão uma visão geral acadêmica acerca de estudos da razão 2D:4D, com vários estudos datados ainda do século XIX (9 estudos datados entre 1875 a 1888) e outros do século XX (17 estudos entre 1924 e 1980). Eles mostram que a medida relativa de 2D:4D foi medido inúmeras vezes pela medida distal das pontas dos dedos, usando o terceiro dedo como referência, ou outras vezes, medindo-se até a pontas dos dedos a partir da prega basal ou a partir da dobradura da pele na junção das falanges ou, ainda, a partir da articulação entre metacarpo e falange.

A mão é formada por três segmentos: (1) pulso ou carpo, (2) palma ou metacarpo e (3) dedos ou falanges. Os ossos do metacarpo, encontrados na palma da mão, são cinco e articulam-se na extremidade proximal com o pulso e na distal com os ossos proximais do dedo (falange proximal). Os ossos dos dedos são compostos por quatorze falanges (nomeadas falanges proximal, medial e distal), sendo três por dedo e apenas duas no dedo polegar. Na palma da mão, o osso do metacarpo que se articula com o dedo indicador (2D) é mais longo que o osso do metacarpo articulado com o dedo anelar (4D). De modo interessante, os metacarpos dos dedos médio, mínimo e indicador (2D), possuem cinco inserções musculares, ao passo que os metacarpos do dedo anelar possuem apenas três. Adicionalmente, as

falanges do dedo indicador possuem sete inserções musculares ao passo que as falanges do dedo anelar possuem apenas seis músculos inseridos. A notável menor mobilidade do dedo anelar, em relação ao indicador e outros dedos, exemplifica estas diferenças. Wood-Jones (1941) questiona se o comprimento dos dedos indicador e anelar não seriam dependentes do comprimento de seus ossos do metacarpo. Phelps (1952) respondeu esta questão analisando dados de Pfitzner (1892) e verificou que o comprimento dos dedos indicador e anelar não apresentava correlação com a razão do comprimento dos metacarpos correspondentes, tanto em homens ($r = -0,12$) quanto em mulheres ($r = 0,01$). Desta forma demostrou que os comprimentos dos dedos independem do comprimento dos ossos do metacarpo.

Em suma, o dimorfismo sexual da razão 2D:4D é evidente desde o século XIX e sabe-se que o desenvolvimento embrionário dos dedos e órgãos sexuais compartilham um controle gênico comum, o que explica compartilharem efeitos do ambiente endócrino no desenvolvimento. No entanto, resta ainda saber qual o papel dos esteroides sexuais na diferenciação da razão 2D:4D e no que os dedos indicadores e anelar se diferenciam dos demais ossos para refletirem exposição diferenciada a hormônios esteroides do período pré-natal.

Recentemente, no estudo experimental de Zheng e Cohn (2011) demonstrou-se que a razão 2D:4D é determinada pelo equilíbrio da testosterona pré-natal (TP) e estrogênio pré-natal (EP), durante uma estreita janela de desenvolvimento fetal dos dedos. Usando um marcador molecular inicial (Sox9) para a determinação da cartilagem nos dígitos em ratos, os autores descobriram que as diferenças sexuais fetais em 2D:4D são estabelecidas entre o dia embrionário 12,5 e 17. Demonstraram também que, durante o desenvolvimento primordial, os dígitos são ricos em receptores de androgênios (RA) e receptores de estrogênio (RE), sendo ainda mais evidente uma maior quantidade, de ambos os receptores, no quarto dígito. Então, utilizando-se de antagonistas dos receptores (flutamida para RA e fulvestrant para RE), concomitante com a administração de di-hidrotestosterona e estradiol, concluíram que a razão 2D:4D é determinada pelo balanço entre TP e EP, agindo sobre o quarto dígito. Em mais detalhe, o tratamento com flutamida diminuiu a proliferação de células no 4º digito dos machos, enquanto que o antiestrogênico (*fulvestrant)* aumentou a proliferação de células no 4º digito das fêmeas, concluindo que os RA presentes no quarto dígito, quando ativados, aumentam a proliferação de

condrócitos, enquanto que a ativação dos RE reduz a proliferação de condrócitos. Assim, a diferença sexual da razão 2D:4D é impulsionada por mudanças no comprimento do quarto dígito e surge a partir dos valores mais elevados de TP em relação a EP encontrado nos machos em comparação com as fêmeas.

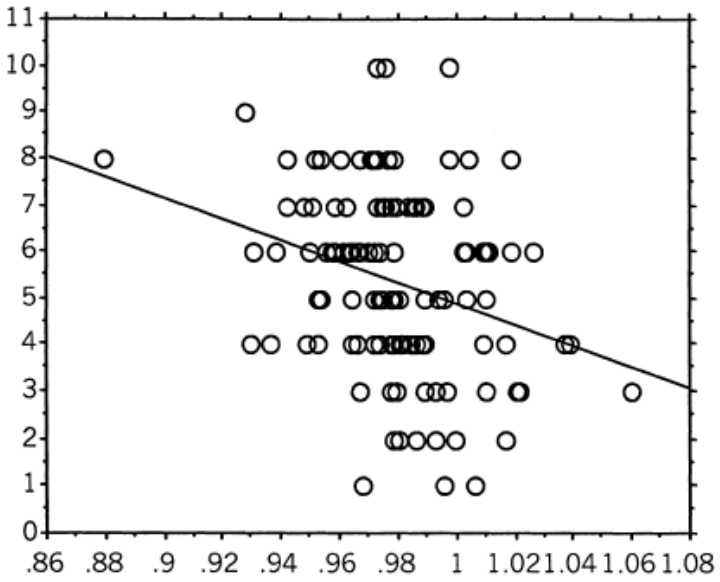
No mesmo estudo, Zheng e Cohn (2011) testaram ainda, o quanto a modulação de androgênio e estrogênio pós-natal afeta a razão 2D:4D. Tratamentos com flutamida, DHT e estradiol, entre os dias 0 a 3 pós-natal, não induziram diferenças significativas na razão 2D:4D medida no dia 21 pós-natal. Porém, este tratamento fez diminuir a distância anogenital (AGD) nos ratos tratados com flutamida ($p = 0,001$) e nos tratados com estradiol ($p = 0,005$). Estes resultados demostraram experimentalmente que a razão 2D:4D é afetada, aparentemente, apenas pela atividade hormonal pré-natal (e não pela ação início de vida), ao passo que AGD reflete tanto a ação hormonal pré-natal quanto pós-natal. Complementarmente, os autores fornecem uma lista de 19 genes que estão envolvidos na formação das falanges do quarto dígito e ainda são sensíveis à TP ou EP. Fica evidente neste experimento que a razão 2D:4D não é apenas determinada pela TP sozinha, mas sim pelo equilíbrio da TP e EP, agindo na sinalização, sob o crescimento dos dígitos, em uma estreita janela de tempo do desenvolvimento fetal. Manning (2011), sugere que a deficiência de muitos estudos com a razão 2D:4D em avaliar a influência da testosterona pré-natal pode ser fruto do ofuscamento da real interação dos hormônios pré-natais (TP e EP).

2.3 A Razão 2D:4D e desempenho esportivo

No âmbito esportivo, existe evidência da relação da razão 2D:4D com o desempenho. O estudo pioneiro demonstrou que a razão 2D:4D estava negativamente associada com o nível de desempenho esportivo autorrelatado, em uma amostra 128 homens recrutados aleatoriamente em bibliotecas e centros esportivos ($b = – 22,73$; $F = 10,99$; $p = 0.001$. **Figura 3**). Em amostra similar (125 homens de bibliotecas e centros esportivos) demostrou-se também associação

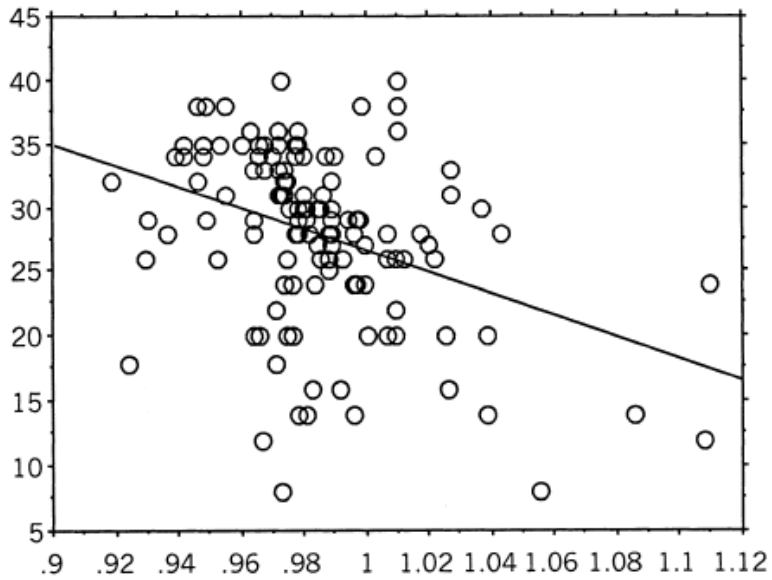
negativa da razão 2D:4D e desempenho em visualização espacial (b = – 83,87; F = 20,17; p= 0,0001; **Figura 4**). Além disso, jogadores de futebol profissional (304) possuíam menores razão 2D:4D, quando comparados com jogadores não profissionais (533) e, ainda, dentre os profissionais, aqueles que atingiram nível internacional, possuíam razão 2D:4D menores que os demais (**Figura 5**). Também no futebol, análises de regressão demonstraram que jogadores titulares possuíam menor razão 2D:4D do que os reservas (John T Manning & Taylor, 2001).

FIGURA 3: A RELAÇÃO ENTRE 2D:4D DAS MÃOS DIREITA E ESQUERDA DE 128 PARTICIPANTES MASCULINOS E NÍVEL AUTORRELATADO DE REALIZAÇÃO ESPORTIVA. SUJEITOS COM BAIXA RAZÃO 2D:4D RELATAM MAIORES RESULTADOS ESPORTIVOS QUE INDIVÍDUOS COM ALTA 2D:4D



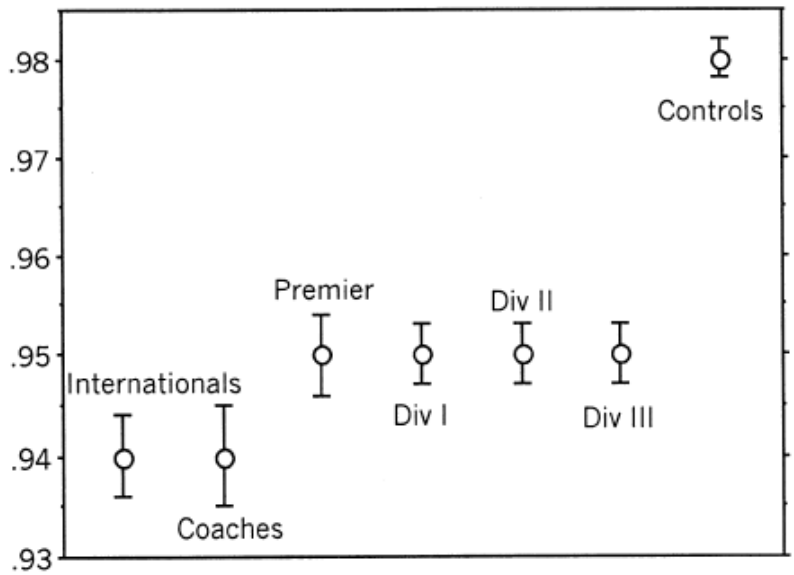
FONTE: (John T Manning & Taylor, 2001)

FIGURA 4: A RELAÇÃO ENTRE A RAZÃO 2D:4D DAS MÃOS DIREITA E ESQUERDA DE 125 PARTICIPANTES DO SEXO MASCULINO E DESEMPENHO EM VISUALIZAÇÃO ESPACIAL.



FONTE: (John T Manning & Taylor, 2001)

FIGURA 5: MÉDIA E ERRO-PADRÃO DA RAZÃO 2D:4D (DIREITA E ESQUERDA) DE JOGADORES DE FUTEBOL PROFISSIONAL E CONTROLES. HÁ UM AUMENTO GERAL NA SEQUÊNCIA: INTERNACIONAIS, TREINADORES (MUITOS DOS QUAIS FORAM INTERNACIONAIS), PREMIER LEAGUE PLAYERS, DIVISÕES I, II E III JOGADORES E CONTROLES.



FONTE: (John T Manning & Taylor, 2001)

Muitas outras investigações surgiram a partir dos estudos pioneiros de (John T Manning & Taylor, 2001) nesse campo. Por exemplo, foi encontrada correlação negativa entre a razão 2D:4D com desempenho em corridas de 800 m e 1500 m (J. T. Manning, 2002a), sugerindo que quanto maior a androgenização pré-natal, maior o desempenho nestas modalidades. Uma relação negativa entre a razão 2D:4D e performance também foi observada em jovens esquiadores (6 a 25 anos) para ambos os sexos (J. T. Manning, 2002b). Em estudo com esgrimistas foi demonstrado que a baixa razão 2D:4D justificava em 12% a performance para o sexo feminino, independente de tempo de experiência, idade, massa corporal e traços de personalidade, porém não para o sexo masculino (Voracek, Reimer, & Dressler, 2010). Em corredores de ambos os sexos, a razão 2D:4D da mão direita e esquerda estava associada, respectivamente, em 20% e 17%, ao maior desempenho em meias maratonas (Longman, Wells, & Stock, 2015).

Uma menor razão 2D:4D foi também correlacionada com maior desempenho esportivo em corridas, em mulheres (Paul, Kato, Hunkin, Vivekanandan, & Spector, 2006) e em meninos (J T Manning & Hill, 2009), com nível de excelência atingido no rúgbi (Bennett, Manning, Cook, & Kilduff, 2010), com melhor desempenho de surfistas em competição (L. P. Kilduff, Cook, & Manning, 2011), com posições mais altas no ranking e melhor índice de vitórias em lutadores de sumô (Tamiya, Lee, & Ohtake, 2012) e melhores tempos de remadoras entre 12 a 30 anos (Hull, Schranz, Manning, & Tomkinson, 2014). No tênis, independente do sexo, tenistas universitários e tenistas de elite possuíam menores índices de razão 2D:4D quando comparados com não atletas (Hsu et al., 2015). Alguns poucos estudos, no entanto, não associação. Por exemplo, na ginástica artística feminina a razão 2D:4D não foi um fator discriminante para o desempenho de ginastas de nível mundial (Peeters & Claessens, 2013) e, ao comparar ginastas e meninas sedentárias, não houve diferença (Peeters & Claessens, 2012).

Embora a maioria dos estudos demonstre relação da razão 2D:4D com desempenho em diversas modalidades esportivas, não se sabe ainda quais componentes da performance são influenciados pela androgenização pré-natal. A força muscular parece ser um dos efeitos, pois baixa razão 2D:4D foi associada com força de preensão manual em populações europeias e asiáticas (Fink, Thanzami, Seydel, & Manning, 2006); em homens americanos, tanto em força máxima como em maior tempo de resistência (Hone & McCullough, 2012); em homens chineses

(Zhao, Li, Yu, & Zheng, 2012; Zhao, Yu, Zhang, & Zheng, 2013) e turcos (Halil et al., 2013) e em crianças do Reino Unido (Ranson et al., 2015). Entretanto, alguns estudos não conseguiram replicar a associação da razão 2D:4D com força de preensão manual (Gallup, White, & Gallup, 2007; Van & Sprengers, 2012) e força de membros inferiores (Folland et al., 2012). Explicações fisiológicas dos efeitos da androgenização pré-natal no desempenho esportivo apontam também para variáveis como consumo máximo de oxigênio (VO2max), sendo que uma menor razão 2D:4D indicaria maior VO2max (Hill et al., 2012).

Aspectos endócrinos poderiam também estar envolvidos na associação da razão 2D:4D com desempenho esportivo. Por exemplo, sabe-se que o polimorfismo do gene do RA se dá pelo número de repetições de trinucleotídeos CAG no exon I do gene responsável pela proteína receptora de androgênio, e quanto maior o número de repetições CAG, menor é a eficiência da proteína RA. Foi apontada correlação positiva entre a razão 2D:4D e o número de repetições CAG, indicando menor funcionalidade do RA e menores efeitos masculinizantes pelos androgênios (Breedlove, 2010; John T. Manning, Bundred, Newton, & Flanagan, 2003). Esta relação da razão 2D:4D com a sensibilidade dos tecidos aos androgênios levou muitos pesquisadores a avaliarem o papel da testosterona circulante atual na relação entre razão 2D:4D com desempenho esportivo. Por exemplo, Folland et al. (2012) não encontraram relação da razão 2D:4D com CAG, testosterona total/livre e força muscular e sugerem que a associação de desempenho esportivo e 2D:4D poderia ser explicada por habilidades motoras e/ou psicológicas. Por outro lado, baixos valores para a razão 2D:4D foram associados ao aumento na concentração de testosterona plasmática em resposta a pequenos desafios físicos (*Sprint*) (L. Kilduff et al., 2013). A partir desses dados, Manning et al. (2014) sugerem que estudos tentando relacionar androgenização pré-natal com a ativação do sistema endócrino e desempenho esportivo precisam controlar o contexto no qual o sujeito é desafiado, de modo a garantir que o desafio simule as situações desafiadoras como as evidenciadas no combate homem a homem, presentes no esporte. Mesmo pequenos estímulos psicológicos ou visuais desafiadores (por meio de vídeos) já são capazes de ativar o eixo endócrino, sendo que indivíduos com baixa razão 2D:4D tendem a apresentar maior liberação de testosterona, o que poderia explicar, em parte, o melhor desempenho esportivo de indivíduos com baixa 2D:4D (B. Crewther, Cook, Kilduff, & Manning, 2015).

Características psicológicas podem ser outro caminho para explorar a relação da androgenização pré-natal com o desempenho esportivo. Por exemplo, pessoas atendidas por fraturas causadas por “brigas” com agressão, apresentam menor razão 2D:4D que o resto da população, corroborando uma possível associação da androgenização pré-natal com agressividade (Joyce et al., 2013). Há, no entanto, muita inconsistência na literatura a respeito dessa relação (ver revisão de HÖNEKOPP; WATSON, 2011). Outro aspecto psicológico, como o autocontrole parece estar associado com a androgenização pré-natal, sendo que uma menor capacidade de autocontrole foi associada com um baixa razão 2D:4D em meninos de 4 a 6 anos, quando submetidos ao teste de resistir a comer um doce (Da Silva, Moreira, & Da Costa, 2014). Já em atletas, o desempenho esportivo, “*mental toughness*”, otimismo, orientação ao objetivo, estratégias de “*coping*” e hostilidade foram relacionados com 2D:4D, especialmente nos atletas de maior nível competitivo, os quais apresentavam menor razão 2D:4D e maiores níveis de autoconfiança e resistência mental para competição (Golby & Meggs, 2011). A baixa razão 2D:4D também foi associada a maiores níveis de autoconfiança em 141 pré-escolares de 4 a 6 anos em tarefas de habilidades motoras como caminhar sobre uma linha e saltar (Da Silva, Moreira, & Da Costa Jr, 2015) e, em adultos, a elevada autoconfiança foi associada a baixa razão 2D:4D no sexo masculino, porém não no feminino. (Neyse, Bosworth, Ring, & Schmidt, 2016).

Um último aspecto a ser abordado quanto ao desempenho está relacionado com diferenças nas habilidades espaciais entre homens e mulheres. Vários estudos apontam para a vantagem de habilidade espacial de atletas cujos apresentam maior androgenização pré-natal (Csathó et al., 2001; Kempel et al., 2005; John T Manning & Taylor, 2001; Sanders, Bereczkei, Csatho, & Manning, 2005; Tlauka, Williams, & Williamson, 2008), o que poderia ser mais uma forma de explicar a associação do desempenho esportivo e razão 2D:4D.

No entanto, há muito ainda a ser investigado tanto nessa área como nos demais aspectos abordados anteriormente para explicar a associação entre razão 2D:4D e performance esportiva. Nesse aspecto, os esportes individuais poderiam ser utilizados em busca de respostas mais claras e diretas nessa associação facilitando, inclusive, a análise dos mecanismos fisiológicos, psicológicos, cognitivos e motores que circundam esta relação da androgenização pré-natal com desempenho.

CAPITULO 3 – ESTUDO 1

Direct vs Indirect Measurement of Digit Ratio (2D:4D): A Critical Review of the Literature and New Data

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Direct Versus Indirect Measurement of Digit Ratio (2D:4D): A Critical Review of the Literature and New Data

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Abstract

Digit ratio (2D:4D: the relative lengths of the second and fourth digits) is widely used as a correlate of prenatal sex steroids. There are two common methods of measuring 2D:4D, the direct method and the indirect method. The modern interest in 2D:4D began 16 years ago when finger lengths were measured directly, but many studies now report 2D:4D calculated from indirectly measured fingers from photocopies or scans. However, there are concerns about the accuracy of the latter in comparison to the former. The purpose of this article was twofold: to review these concerns and to add new data to the debate. Our review shows that in 2005, directional effects in indirect 2D:4D were reported such that direct 2D:4D > indirect 2D:4D. This finding was challenged by a 2006 report that direct 2D:4D was lower (not higher) than indirect 2D:4D for male right-hand 2D:4D. Two further studies from the same group have claimed that indirect 2D:4D may be lower, higher, or comparable to direct 2D:4D. More recent comparisons of direct 2D:4D versus indirect 2D:4D and a meta-analysis of Chinese studies have replicated the finding of direct 2D:4D > indirect 2D:4D. We considered an additional sample and found significant direct 2D:4D > indirect 2D:4D for three of four ratios. The overall literature is discussed within the context of standards of research (sample size) and publishing (clarity of report). It is concluded that direct 2D:4D does tend to be greater than indirect 2D:4D. Implications for comparative studies and other aspects of research in 2D:4D are discussed.

Keywords

2D:4D, direct versus indirect measurement, statistical power, publishing standards

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Introduction

Digit ratio is the relative lengths of the index finger (2D) and the ring finger (4D), that is, 2D:4D (Manning, Scutt, Wilson, & Lewis-Jones, 1998). Precise measurement of 2D:4D is important because most individuals show differences in the lengths of 2D and 4D of the order of a few millimeters. It has been known for many years that 2D:4D is sexually dimorphic such that male 2D:4D < female 2D:4D (Baker, 1888). However, much of the recent interest in 2D:4D as a marker for the fetal formation of the reproductive system, ejaculate size, and the secretion of prenatal sex steroids dates from the report of Manning, Scutt, Wilson, and Lewis-Jones (1998). Finger length in the Manning et al.'s (1998) paper was measured directly from the fingers, with measurement landmarks consisting of a midpoint in the proximal ventral flexion crease of the finger and the distal tip of the finger. A UK sample of 800 (400 males) participants with an age range of 2 years –25 years gave a mean of 0.98 for males and 1.00 for females. These means probably represent approximate values for 2D:4D in Caucasians. Further work suggested that ethnic differences existed in mean 2D:4D such that Caucasian 2D:4D > East Asian 2D:4D > Black 2D:4D (Manning et al., 2000; Peters, Mackenzie, & Bryden, 2002) and that there may be between-nation differences in Caucasian mean 2D:4D (Manning, 2002). However, comparative work concerning

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between-population differences in 2D:4D may have been adversely affected by artifacts introduced by the process of indirectly measuring finger lengths.

The Manning et al. (1998) report measured finger length directly on the fingers. This method is costly in terms of participant time and may be affected by such things as movement of the participants' fingers. This led Robinson and Manning (2000) to measure finger length indirectly from photocopies of the hand. It was found that a comparison between direct and indirect 2D:4D gave high intraclass correlation coefficients (ICCs; Robinson & Manning, 2000), and as a consequence, indirectly measured 2D:4D (often from photocopies or scans) has been reported by many subsequent studies. However, there is a problem in the comparison of direct versus indirect 2D:4D using ICCs. Values of ICC are not sensitive to directional effects. Thus, direct 2D:4D may be consistently higher than indirect 2D:4D, and the directionality of the effect would not influence the ICC. If direct 2D:4D > indirect 2D:4D, it is important to understand the properties of indirect 2D:4D in relation to direct 2D:4D.

The purpose of this study was twofold: to review research on the issue of direct versus indirect measurement of digit ratio and to add new data to the debate. Manning, Fink, Neave, and Caswell (2005) have presented evidence that 2D and 4D finger lengths measured indirectly may give mean 2D:4D values that show directional effects such that direct 2D:4D > indirect 2D:4D. If these findings are correct, it is important that direct and indirect mean 2D:4D's should not be included together in between-population studies, and we should understand the possible limitations concerning indirect 2D:4D. Here the attempts to replicate the Manning et al.'s (2005) finding are reviewed. The review considers possible limitations in this literature, which may include issues of power and lack of clarity in report. New data are also presented which consider the directional effect of indirect 2D:4D. The direct 2D:4D > indirect 2D:4D relationship is discussed from the viewpoint of comparative studies and other aspects of research in 2D:4D.

Method

The Review

We report a narrative review of the Manning et al.'s (2005) study and the replications of this work. We searched for reports concerning direct and indirect measurement of 2D:4D using PubMed and the Web of Science. The search terms were digit ratio, 2D:4D, finger lengths, direct measurement, and indirect measurement. Our criteria for inclusion in the review were that mean and *SD* for direct and indirect 2D:4D should be given for the same sample rather than comparisons of subsamples. In addition, it was required that finger length was measured by experimenters rather than self-measured.

Direct Versus Indirect Data

The participants were recruited from students and staff of a UK University. Approval was provided by the local ethics committee, and informed consent was signed before the study commenced.

Finger lengths were measured directly and from scans with digital callipers, measuring to 0.01 mm. All hands were scanned in pdf format using a Canon Canoscan LiDE 700F scanner whose maximum optical resolutionwas 4800 dpi, and mechanical resolution was 9600 dpi.

Direct measurements were taken from the fingers. The sequence of measurement was as follows: The second and fourth fingers were measured from the right hand and then the left. This sequence was then repeated such that the second and fourth fingers were measured twice. Measurement was of the ventral surfaces of the second and fourth fingers from a midpoint on the ventral crease proximal to the palm, to the tip of the finger. With regard to the scans, participants were asked to gently place their hands palm down on the glass platen. A scan was taken and checked for clarity at the ventral crease and the tip of the finger. Measurements (indirect) were made using the same landmarks as were used for direct measurement, and fingers were measured twice.

Results

The Review

Manning et al. (2005) suggested that there was a tendency in the 2D:4D literature between 2000 and 2005 for mean direct 2D:4D to be higher than that of mean indirect 2D:4D. Focusing on this possibility, they compared direct and indirect 2D:4D in 50 men and 70 women. They found that mean direct 2D:4D was higher than mean indirect 2D:4D. We have here directional effects such that, in comparison to direct measurements, indirectly measured 4D is relatively longer than 2D. Direct and indirect mean 2D:4D, *SD*s, and the effect sizes (Cohen's *d*) of the difference in 2D:4D between the 2 protocols are given in Table 1 and Figure 1. All four values of *d* were positive (direct 2D:4D > indirect 2D:4D), one was not significant (females right 2D:4D, $d = +.10$), but the remainder were significant with *d* varying from +.20 to +.5.

There have been eight replications of the Manning et al. (2005) UK report. Three of these were from Austria (the Voracek lab) and five from labs in Canada, Saudi Arabia, Spain, South Korea, and the United States. The Voracek lab reported a variety of effects, with direct 2D:4D < indirect 2D:4D; direct 2D:4D ≈ indirect 2D:4D; and direct 2D:4D > indirect 2D:4D, and the remaining five labs reported all relationships to be direct 2D:4D > indirect 2D:4D. We first consider the Voracek reports.

The first replication was that of Voracek and Dressler (2006; see Table 1 and Figure 1). The sample comprised 30 Austrian men, and only the right hand was measured. Each hand was measured in four ways: (i) directly on the ventral surface of the fingers; (ii) indirectly from scans of the ventral surface of the fingers; (iii) indirectly from dorsal (palm down) hand outline drawings; and (iv) indirectly from hand-outline drawings (palm up). For our purposes, we must focus on methods (i) and (ii).

Table 1. Mean 2D:4D (Males Right and Left 2D:4D and Females Right and Left 2D:4D) for Direct and Indirectly Measured Fingers and the Difference (Direct–Indirect) and Effect Size of the Difference in Means.

Study	2D:4D Trait	*n*	Direct Mean (*SD*)	Indirect Mean (*SD*)	Direct–Indirect	Effect Size
Manning et al. (2005), Austria & England	Male right	50	.968 (.033)	.956 (.029)	+.012*	+.39
	Male left	50	.981 (.034)	.963 (.033)	+.018*	+.54
	Female right	50	.982 (.031)	.979 (.028)	+.003	+.10
	Female left	50	.987 (.031)	.981 (.030)	+.006*	+.20
Voracek and Dressler (2006), Austria	Male right	30	.953 (.031)	.963 (.033)	−.010*	−.31
Voracek and Offenmuller (2007), Austria	Male right	60	.969 (.028)	.961 (.028)	+.008*	+.29
	Male left	60	.967 (.026)	.955 (.027)	+.012*	+.45
	Female right	64	.976 (.033)	.977 (.034)	−.001	−.03
	Female left	64	.978 (.028)	.969 (.031)	+.009*	+.31
Dressler and Voracek (2011), Austria	Male right	75	.956 (.027)	.953 (.024)	+.003*	+.12
	Male left	75	.973 (.03)	.955 (.028)	+.018*	+.62
	Female right	75	.961 (.029)	.964 (.031)	−.003	−.10
	Female left	75	.980 (.029)	.966 (.029)	+.014*	+.48
Allaway, Bloski, Pierson, and Lujan (2009), Canada	Male mean	30	.966 (.03)	.956 (.035)	+.014*	+.31
	Female mean	30	.983 (.983)	.973 (.029)	+.010*	+.34
Almasry, El Domiaty, Algaidi, Elbastawisy, and Safwat (2011), Saudi Arabia	Male right	276	.98 (.04)	.96 (.03)	+.02*	+.57
	Male left	276	.97 (.04)	.96 (.04)	+.01*	+.25
	Female right	284	.98 (.04)	.976 (.037)	+.004*	+.10
	Female left	284	.99 (.04)	.97 (.04)	+.02*	+.50
Costas et al. (2013), Spain	Male right	24	.978 (.038)	.971 (.027)	+.007	+.21
	Male left	24	.979 (.038)	.971 (.037)	+.008	+.21
	Female right	26	.991 (.980)	.980 (.028)	+.011	+.35
	Female left	26	.978 (.033)	.974 (.026)	+.004	+.14
Kim and Cho (2013), Korea	Male right	115	.962 (.03)	.949 (.03)	+.013*	+.43
	Male left	115	.961 (.03)	.945 (.03)	+.016*	+.53
	Female right	157	.972 (.03)	.961 (.03)	+.011*	+.37
	Female left	157	.970 (.03)	.962 (.03)	+.008*	+.27
Shaw, Kotowski, Bostor, and Levine (2012), United States	Male right	201	.98 (.03)	.95 (.03)	+.03	+1.00
	Male left	201	.97 (.03)	.95 (.03)	+.02	+.67
	Female right	204	.99 (.03)	.97 (.03)	+.02	+.67
	Female left	204	.98 (.03)	.97 (.03)	+.01	+.67

Note. The effect size is positive when direct 2D:4D > indirect 2D:4D and negative when direct 2D:4D < indirect 2D:4D. The *p* values included are from paired *t* tests reported in the relevant papers.
*significant $p < .05$ or less.

Voracek and Dressler (2006) reported that direct measurement yielded *lower* 2D:4D than that from indirect scans ($d = -.31$, note the negative effect size). They pointed out that this "was exactly the opposite of what Manning et al. (2005) found."

The remaining two reports from the Voracek lab consisted of a mix of positive and negative effects (Figure 1). With regard to Voracek and Offenmüller (2007), the effect sizes for direct versus indirect 2D:4D comparisons are difficult to identify as they are reported along with finger ratios that are other than 2D:4D (e.g., 2D:3D, 2D:5D, ...). However, careful reading of this article indicates of the four possible 2D:4D comparisons, three show positive and significant effect sizes, that is, males right $d = +.29$; males left $d = +.45$; and females left $d = +.31$; all $p < .05$. There was one very small negative effect size, females right $d = -03$, not significant (*ns*). This finding for 2D:4D replicates the findings of Manning et al. (2005) by sex and hand and is a nonreplication of Voracek and Dressler (2006).

With regard to Dressler and Voracek (2011), in contrast to Voracek and Offenmüller (2007), the effect sizes for direct versus indirect ratios are clearly set out for 2D:4D as against all other ratios. There are again similar results for 2D:4D to that of Manning et al. (2005), in that there are three positive and significant effect sizes, these are by sex and hand: males right $d = +.12$and left $d = +.62$; females left $d = +.48$; all $ps < .05$. For female right 2D:4D, there was a negative effect size which was not formally significant ($d = -.10$, *ns*.). Therefore, this is another nonreplication of Voracek and Dressler (2006).

There are five other replications of the direct 2D:4D > indirect 2D:4D hypothesis (Table 1, Figure 2). The reports are from five independent labs, five nations (Canada, Saudi Arabia, Spain, South Korea, and the United States), and two macroethnic groups (Caucasians and East Asians). Sample sizes varied from $n = 24$ to $n = 284$. There were 18 effect sizes, and none of these yielded the Voracek and Dressler (2006) effect. Of importance, all effect sizes were positive, that is, they

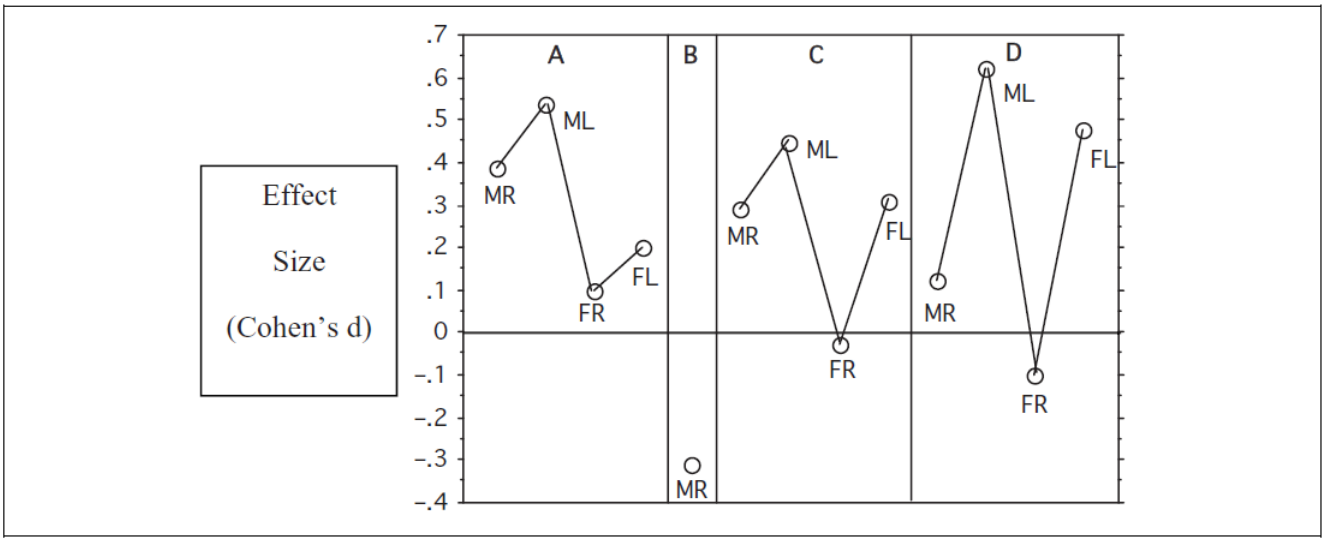

Figure 1. Effect sizes (Cohen's *d*) for the difference between mean 2D:4D from direct measurement and indirect measurement (direct–indirect). A = Manning et al., 2005; B = Voracek & Dressler, 2006; C = Voracek & Offenmüller, 2007; and D = Dressler & Voracek, 2011). Positive values denote direct mean 2D:4D > indirect mean 2D:4D and negative values denote direct mean 2D:4D < indirect mean 2D:4D. M = male and F = female; R = right hand and L = left hand. The effect sizes for the four 2D:4D ratios are connected with solid lines to facilitate recognition of the similarities in pattern between studies A, C, and D and the discrepant nature of the results of study B.

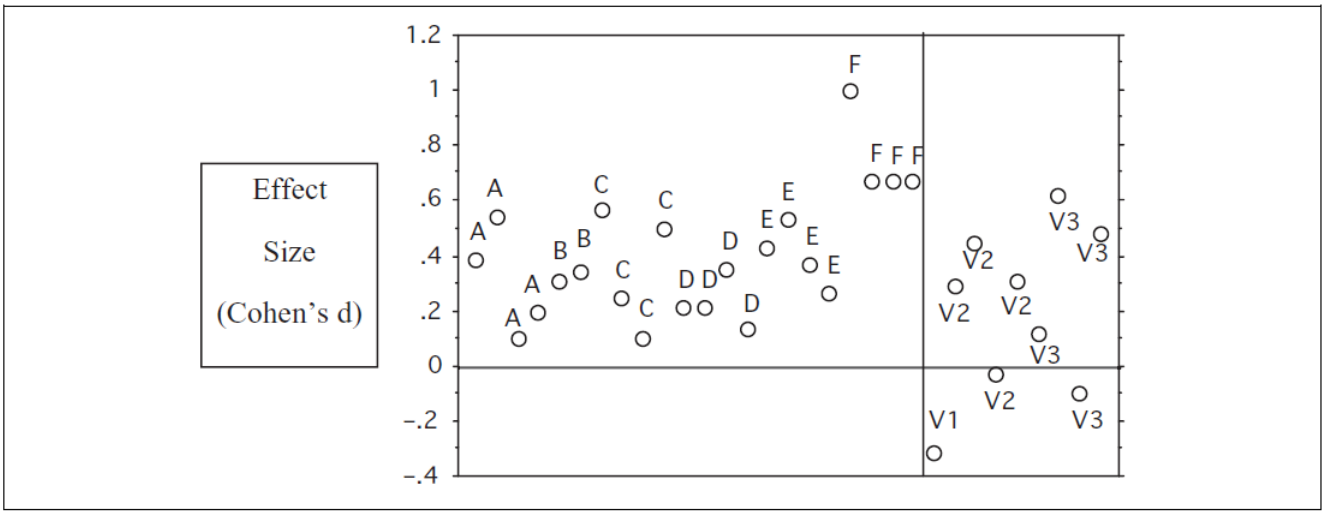

Figure 2. Effect sizes (Cohen's *d*) for the difference between mean 2D:4D from direct measurement and indirect measurement (direct–indirect). A = Manning et al. (2005); B = Allaway, Bloski, Pierson, and Lujan (2009); C = Almasry et al. (2011); D = Costas et al. (2013); E = Kim and Cho (2013); and F = Shaw, Kotowski, Bostor, and Levine (2012). All these effect sizes ($n = 22$) are positive, that is, they denote direct mean 2D:4D > indirect mean 2D:4D. V denotes studies from the Voracek lab,that is, V1 = Voracek and Dressler (2006); V2 = Voracek and Offenmüller (2007); and V3 = Dressler and Voracek (2011). Of nine effect sizes from this lab, three are negative (direct mean 2D:4D < indirect mean 2D:4D), albeit only one of these is significant.

denoted direct mean 2D:4D > indirect mean 2D:4D, they ranged from $d = +.10$ to $+1.00$.

The effects of direct versus indirect measurements of 2D:4D are best investigated by applying both measurement procedures to the same subjects. However, we can also obtain valuable information by comparing means for direct and indirect 2D:4D across a number of studies. There is one such relevant meta-analysis. Xu and Zheng (2015) considered 2D:4D in China (mainland and Taiwan), with means for 2D:4D in 28 studies, 112 independent samples and 19,093 participants. As expected, there was a sex difference in 2D:4D with lower mean for males compared to females. However, method of measurement (direct vs. indirect) was a significant moderator variable. With regard to males, for right-hand 2D:4D, there were 14 directly measured ($n = 2{,}790$) and 15 indirectly measured ($n = 1{,}698$) samples. Consistent with the findings of Manning

et al. (2005) but counter to that of Voracek and Dressler (2006), the mean for the former was significantly greater than the mean for the latter (direct .953 vs. indirect .942, between study homogeneity statistic $Q_b = 5.0$, $p < .05$). For left 2D:4D, there were 14 ($n = 2{,}790$) and 13 ($n = 1{,}430$) samples for direct and indirect measurement, respectively. Mean direct 2D:4D was .955 compared to .947 for indirect 2D:4D ($Q_b = 2.66$, $p > .05$). With regard to females, for right hand 10 direct ($n = 2{,}156$) samples gave a mean of .961 and 15 indirect ($n = 1{,}958$) samples a mean of .956, $Q_b = .64$, $p > .05$. For left hand, 10 direct ($n = 2{,}156$) samples gave a mean of .960 and 15 indirect ($n = 1{,}792$) samples a mean of .958, $Q_b = .12$, $p > .05$. Thus, there was an overall tendency for higher mean direct 2D:4D compared to indirect 2D:4D.

Direct Versus Indirect 2D:4D: New Data

There were 114 male and 90 female participants in the sample. With regard to direct measurement, the repeatability (intraclass coefficient; r_1) of the first and second measurements of 2D:4D was high and significant for right 2D:4D (males and females $r_1 = .987$, $p < .0001$; males $r_1 = .989$, $p < .0001$; and females $r_1 = .984$, $p < .0001$) and somewhat lower but still significant for left 2D:4D (males and females $r_1 = .983$, $p < .0001$; males $r_1 = .989$, $p < .0001$; and females $r_1 = .977$, $p < .0001$). In comparison, the first and second indirect measurements gave even higher r_1 values for both right 2D:4D (males and females $r_1 = .998$, $p < .0001$; males $r_1 = .998$, $p < .0001$; and females $r_1 = .998$, $p < .0001$) and left 2D:4D (males and females $r_1 = .998$, $p < .0001$; males $r_1 = .997$, $p < .0001$; and females $r_1 = .998$, $p < .0001$). The high repeatability values for both types of measurement indicated that the between-individual differences in 2D:4D were significantly greater than the measurement error. Therefore, we calculated the mean of the first and second 2D:4D for direct and indirect measurement.

There were significant sex differences in 2D:4D with higher values in females compared to males. The mean values ($\pm SD$) of 2D:4D from direct measurement were: right 2D:4D males = .969 $\pm$ .030, females = .983 $\pm$ .029, $t = 3.44$, $p = .0007$, $d = .47$; left 2D:4D males = .966 $\pm$ .029, females .978 $\pm$ .033, $t = 2.77$, $p = .006$, $d = .39$. For indirect measurement, the means were right 2D:4D males = .961 $\pm$ .031, females = .975 $\pm$ .032, $t = 3.17$, $p = .002$, $d = .44$ and left 2D:4D males = .961 $\pm$ .029, females = .975 $\pm$ .034, $t = 3.36$, $p = .0009$, $d = .46$. Thus, the effect size (Cohen's d) varied from $d = .39$ (direct) to $d = .47$ (direct).

For both right and left 2D:4D, the male direct measurement means were significantly greater than the indirect means, paired t-test direct (x)–indirect (y): right 2D:4D x–$y = .008$, $t = 6.89$, $p < .0001$, $d = .26$; left 2D:4D x–$y = .005$, $t = 4.16$, $p < .0001$, $d = .21$. For females, the directional effects of indirect measurement were somewhat weaker than those found for males. Direct mean 2D:4D was significantly greater than indirect mean 2D:4D for the right hand (x–$y = .008$, $t = 4.64$, $p = < .0001$, $d = .26$). The difference was positive for the left hand but not significant (x–$y = .003$, $t = 1.42$, $p = .16$, $d = .09$). The effect size for right 2D:4D (male and female) and for left 2D:4D (male only) was about half the effect size for sex differences in 2D:4D.

Discussion

It is difficult to successfully navigate through the world of direct versus indirect 2D:4D measurement. However, the evidence from our review points to the following: (i) Manning et al. (2005) reported differences between mean direct 2D:4D and mean 2D:4D in a Austria/UK study such that the former is greater than the latter. The differences were significant for three of the four possible ratios. (ii) There are three reports from Austrian studies of direct 2D:4D < indirect 2D:4D, they are lab specific and are significant for only one instance of direct right-hand 2D:4D < indirect right-hand 2D:4D for males only. This single study was not replicated in two additional studies by the same lab. In both the latter studies, they found significant direct 2D:4D > indirect 2D:4D, for three of the four possible 2D:4D ratios (i.e., six ratios in total). (iii) Five studies from Canada, Saudi Arabia, Spain, South Korea, and the United States reported 18 positive effect sizes for direct 2D:4D > indirect 2D:4D. (iv) A meta-analysis of Chinese 2D:4D studies reported direct 2D:4D > 2D:4D, and this was significant for right-hand male 2D:4D. With regard to our new data, we have found significant positive effect sizes such that direct 2D:4D > indirect 2D:4D in three of four ratios with d values ranging from .21 to .26. These effect sizes are about half those found for sex differences in 2D:4D. The remaining ratio (female left 2D:4D) showed a positive but nonsignificant effect size ($d = .09$).

Therefore, it seems that there is convincing evidence that direct 2D:4D > indirect 2D:4D. However, there are still concerns with this conclusion. That the overall picture is not as clear as it might be could result from limitations in standards of research (issues of power) and publishing (issues of clarity of report) which may have caused some confusion.

Power Issues

Statistical power calculations appear to support the view that the Voracek and Dressler (2006) study was underpowered. If the true population effect for mean direct 2D:4D—mean indirect 2D:4D was indeed $d = -.31$, then with a sample of $n = 30$, one would have merely 38% power to detect a significant deviation in the mean from 0 (two-tailed test). Note that it is inappropriate to apply a one-tailed test here, as the Voracek and Dressler (2006) effect was opposite to that of Manning et al. (2005). However, even with a one-tailed test, the power to detect a significant deviation from 0 would only be 51%. This is far from a reasonably high power which is often taken as 80%.

Publishing Standards

With such low power, it would have been advisable to include a replication in the Voracek and Dressler (2006) report. The

absence of a replication negatively affects publishing standards. Two further replications were published by Voracek and Offenmuller (2007) and Dressler and Voracek (2011). However, there are issues here that may relate to clarity of report which affect publishing standards and which may have caused confusion in the literature. In these studies, there were six significant positive effect sizes and no significant negative effect sizes for 2D:4D. Despite this, differences between direct and indirect ratios were reported as a mix of positive and negative effect sizes, many of them were significant. Thus, in Voracek and Offenmüller (2007, p. 151), we have the following statement "the current data do not indicate that image-based measurements necessarily yield lower digit ratios (Manning, Fink, Neave, & Caswell, 2005). In point of fact compared with direct finger measurements, they yield lower, comparable, or even higher digit ratios (such as observed in the measurement study of Voracek & Dressler, 2006) for both men and women." In addition, Dressler and Voracek (2011, p. 75) stated "the hypothesis that image-based digit ratios are uniformly lower than directly measured ones was not supported". The apparent discrepancy between the actual findings and the report of the findings arises because Voracek and Offenmuller (2007) and Dressler and Voracek (2011) reported direct versus indirect comparisons for 2D:4D and five other finger ratios. It is in these latter ratios, not in 2D:4D, that they found all their significant negative effect sizes. They found no such effects for 2D:4D, and Manning et al. (2005) did not consider finger ratios other than 2D:4D. In addition, there seems to be clarity issues in later reports. Thus, Voracek et al. (2008, p. 508) state "Of note, results from one lab, indicating that image-based methods may uniformly yield lower 2D:4D than direct measurements (Caswell & Manning, 2009; Manning et al., 2005), have not been replicated (Voracek & Dressler, 2006; Voracek & Offenmüller, 2007)." This statement of null replication appears to be incorrect for Manning et al. (2005) versus Voracek and Offenmüller (2007), as the latter replicates the findings of Manning et al. (2005), that is, significant differences in direct 2D:4D > indirect 2D:4D for male right and left hand and female left hand.

In the light of the abovementioned findings, what are we to make of the report of direct 2D:4D < indirect 2D:4D by Voracek and Dressler (2006)? Consequent to this study, five independent groups have failed to replicate this single effect size. There have been two replication attempts by Voracek and colleagues. Putting aside possible issues regarding clarity of report, they failed to find a single significant example of direct 2D:4D < indirect 2D:4D. In addition, after a meta-analysis of Chinese mean 2D:4D's and a consideration of evidence that they were modified by measurement method, Xu and Zheng (2015) concluded that Voracek and Dressler's (2006) report was incorrect. Therefore, it may be best to regard the Voracek and Dressler's (2006) finding as a chance event resulting from power issues with a sample size of $n = 30$. However, there is another, albeit unlikely, possibility. It is well known that there are significant ethnic and national effects on 2D:4D. It may be that there is some aspect of Austrian 2D:4D which lends itself to distortional effects of indirect measurement such that (in comparison to direct 2D:4D) it shows a mix of positive and negative effects. This should be borne in mind in further work concerning direct versus indirect measurement effects.

If we have arrived at the conclusion that the available evidence indicates direct 2D:4D > indirect 2D:4D, we must address a number of questions. Firstly, what is the mechanism that results in these directional effects of indirect 2D:4D? Secondly, does it matter whether direct or indirect 2D:4D is used in studies? Thirdly, what is the way forward with regard to measurement method in 2D:4D studies?

With regard to the first question, the mechanism that drives indirect 2D:4D down in comparison to direct 2D:4D is unknown. However, it is likely to involve one or both measurement points on the fingers, that is, the tip of the finger and the basal crease. Manning et al. (2005) pointed out that indirect methods involve placing the fingers on the glass plate of the photocopier or scanner. Downward pressure of the hand may distort the fleshy tips of the fingers, the pressure may vary according to sex and even according to personality types. These factors may reduce 2D:4D, particularly if distortion of the fat pad at the tip of the fourth finger was greater than that of the second finger. There has been one test of this suggestion. Voracek et al. (2008) have examined fingertip size in relation to indirect finger measurements. They found large differences in fingertip size but claimed none of these influenced image-based 2D:4D measurements. However, their study did not consider direct measurements. Therefore, the null conclusions of Voracek et al. (2008) should be treated with caution. The second measurement point is to be found at the midpoint of the ventral basal crease of the finger, which is proximal to the palm. This crease is established early in utero, but it is a soft tissue marker and lies about halfway along the proximal phalanx of the digit. One possibility relating to directional effects involves movement of this crease, when the palm is turned downward onto the glass plate of the photocopier or scanner. In short, it is worth considering that nonconcordance of direct and indirect measurement points at the tip and base of the finger may lead to directional effects in indirect 2D:4D.

Considering the second question, if direct 2D:4D shows stronger relationships with target traits than indirect 2D:4D, then measurement protocol does matter in 2D:4D studies. There have been three studies that considered differences in the strength of direct and indirect 2D:4D with target traits (including facial-metrics, Burriss et al., 2007; body size, Almasry, El Domiaty, Algaidi, Elbastawisy, & Safwat, 2011, and dermatoglyphics, Dressler & Voracek, 2010). In comparison to indirect 2D:4D, Burris et al. (2007) and Almasry, El Domiaty, Algaidi, Elbastawisy, and Safwat reported stronger correlations between direct 2D:4D and facial metrics or body size. Dressler and Voracek (2011) found no significant correlation between 2D:4D (direct or indirect) and dermatoglyphics. Further work is needed in order to clarify whether the strength of associations between 2D:4D and its target trait is dependent on measurement protocol.

With regard to the way forward, we should not include direct and indirect samples together in comparative studies of

2D:4D. This became clear in 2005. Comparative studies before this date should be considered with caution (e.g., see Manning, 2002), and where possible, allowance should be made for differences in measurement method. We should disregard the results of comparative studies after 2005 if they mix direct and indirect samples. Two examples relating to comparative differences in 2D:4D between nations and changes in 2D:4D within nations will suffice to illustrate this problem. An example of the former is afforded by the report of very high mean 2D:4D (>1.00) in Danish men by Bang et al. (2005). This study employed an unusual measurement protocol for 2D:4D which may be the source of their high mean 2D:4D. Voracek and Dressler (2006) considered the effect of the Bang et al. (2005) protocol and concluded that it produced mean 2D:4D which was not significantly different from that of indirect 2D:4D. In view of the power concerns regarding the Voracek and Dressler (2006) report, it would be advisable to reconsider the issue of a high 2D:4D for Danish men. Thus, a comparison of self-reported directly measured 2D:4D for 29 countries showed, for right-hand male 2D:4D, a Danish mean of .982. This was lower than that of 18 of the 29 countries concerned (Manning, Fink, & Trivers, 2014). Therefore, comparative data using direct finger measurement in a large ($n > 250,000$) multinational sample do not support the notion of a very high 2D:4D in Danish men. The magnitude of the mean 2D:4D reported by Bang et al. (2005) may indeed have been related to the method of finger measurement they employed. With regard to comparative changes in 2D:4D within nations, an appropriate example is that of putative change in 2D:4D within Lithuania between samples from the 1880s and modern populations. Digit ratio was measured in the 1880s, and these potentially valuable measures compared to indirect 2D:4D measured in a contemporary sample (Voracek et al., 2007). There were significant differences between the two samples. Time-dependent change in 2D:4D may indicate the modern influence of endocrine disruptors in the environment. However, the sample from the 1880s was measured using a rather unusual direct method, and the modern participants were measured using a standard indirect method. The authors of the study noted the potential for differences in the two measurement protocols to invalidate their comparisons. Their caution was probably correct. It is emphasized that time-dependent and space-dependent comparisons of mean 2D:4D must control for measurement protocol.

What of current studies? What is the "best" method for measuring finger length? Well, this depends on the study. If small numbers of participants are involved and there is adequate time to measure, then direct measurements are indicated. For large samples and/or samples that require fast measurement, indirect measurement may be appropriate. However, for the latter, it may be wise to ensure that participants are instructed to lightly place their hand on the glass plate of the photocopier/scanner.

In conclusion, a comparison of direct and indirect 2D:4D shows the former tends to be larger than the latter (i.e., direct 2D:4D > indirect 2D:4D). Most labs that have considered this issue have concluded that this is so. Reports of direct 2D:4D < indirect 2D:4D are lab specific although we cannot exclude the possibility that they may be nation-specific. The directional effect of indirect 2D:4D is complex and is little understood, and there are many reports of indirect 2D:4D in the literature. Therefore, we need to understand its effect on 2D:4D. Further work is indicated to elucidate this and should include samples from a number of countries (all nonreplications thus far are reported from Austria, and data from this nation would be particularly valuable) and ethnicities. Suggestions for the appropriate use of direct and indirect methodologies in 2D:4D research are discussed.

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CAPITULO 4 – ESTUDO 2

Digit ratio (2D:4D), testosterone, cortisol, aggression, personality and handgrip strength: Evidence for prenatal effects on strength.

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Digit ratio (2D:4D), testosterone, cortisol, aggression, personality and hand-grip strength: Evidence for prenatal effects on strength

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ABSTRACT

Background: Digit ratio (2D:4D) is a putative marker for prenatal testosterone and is correlated with performance in many sports. Low 2D:4D has been linked to strength but the evidence is mixed and strength is also influenced by mass, testosterone, and behavioural factors. It has been hypothesised that the 2D:4D-strength correlation may be strongest in challenge conditions when short-term changes occur in steroid hormones.
Aims: We tested this suggestion in men.
Study design: We used a cross-over study design with a challenge (an aggressive video of rugby tackles) and control (a blank screen) condition.
Subjects: 89 healthy men.
Outcome measures: Finger lengths (2nd and 4th for both hands), hand-grip strength (HGS), testosterone (T), cortisol (C), aggression (Buss-Perry Aggression Questionnaire) and personality type (Ten Item Personality Measure). In both conditions participants provided saliva samples (for hormone assays).
Results: In the challenge condition there was a highly significant increase in HGS, and modest changes in T, physical aggression and emotional stability. HGS correlated negatively with left hand 2D:4D. In a multiple regression, left hand 2D:4D was negatively related to HGS and emotional stability was positively related to HGS. In the control condition HGS was not correlated with 2D:4D. In a multiple regression, BMI, physical aggression, and emotional stability were significantly related to HGS.
Conclusions: 2D:4D is a negative correlate of strength in challenge situations. This finding may in part explain associations between 2D:4D and sports performance.

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1. Introduction

Digit ratio (2D:4D; a putative negative correlate of prenatal testosterone [T] and a positive correlate of prenatal oestrogen [E]) is negatively related to performance in a number of sports [1,2]. Thus, it is reasonable to assume that, at least in part, a negative relationship between 2D:4D and physical strength influences the 2D:4D and sport correlation. Low 2D:4D has been found to be associated with high handgrip strength (HGS) in samples of European (German) and Asian (Mizos) men [3]. This finding has been replicated in a sample of US men [4], in Chinese men of Han [5] and Hani [6] ethnicity, in Turkish older men [7], and in boys from the UK [8]. However, other studies including US and European samples failed to replicate the link between 2D:4D and strength in men (for HGS [9,10] and leg-strength [11]). Conditions of challenge and male-male competition are associated with short-term increases in adult T and the magnitude of increases in T is correlated with 2D:4D and strength [12]. Therefore, we hypothesised that 2D:4D would correlate negatively with HGS in men, and that the context in which strength is measured affects the magnitude of this relationship. That is, we suggest that in a challenge condition the correlation between 2D:4D and HGS would be greater than in the control condition (without a challenge).

Handgrip strength is sexually dimorphic (with men typically being stronger than women [13]), highly heritable [14], and it predicts total muscle strength in children, adolescents and young adults [15].

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Compared to men with low HGS, men with high HGS live longer [16], have greater density of their bones [17], show less developmental instability [18], and are rated as better dancers [19]. In addition to 2D:4D, the predictors of HGS have been reported to include total body mass, and fat-free mass [20,21], T [22,23], aggression [24], and Big Five personality constructs e.g., neuroticism [21].

Challenge conditions, including intense exercise and aggressive videos, can result in short-term increases of T [12,25–28], aggression [29–31] and strength [26,32]. It is unclear whether challenge-conditions influence personality. For example, it has been reported that competitive conditions increase T and antagonistic behaviour in men but T did not interact with other personality measures [33].

There is evidence that 2D:4D relates to short-term competition-induced T and C production, aggression and aspects of personality. For example, low right 2D:4D and low right-left 2D:4D (Dr-l) have been reported to be associated with spikes in testosterone production in conditions of intense exercise [25], and T and C peaks in response to a combination of intense exercise and aggressive stimuli [12]. Baseline T levels are only weakly related to aggression, but in conditions of challenge and male-male competition increases in T become linked to increases in aggression [30]. Correlations between 2D:4D and aggression in men are also weak and often non-significant [34]. However, in challenge conditions the negative relationship between 2D:4D and aggression becomes significant [35] and has been associated with increases in T [29]. Aspects of personality may also modulate physical strength, for example, there are negative relationships of HGS with neuroticism, independent from the influence of age and BMI [21].

In order to understand muscular strength, we must consider it in situations in which it is relevant to survival and competition. Strength is sexually dimorphic such that men on average are stronger than women and the dimorphism is likely to have arisen as a response to selection pressures associated with male-male competition [13]. Therefore, strength in men is likely to be particularly important in the context of challenge and aggression. The predictors of male strength may therefore differ between base-line non-challenge conditions and contexts that involve male-male aggressive interactions for resources such as mates and status. We predicted a negative association of 2D:4D with HGS and that this association would be stronger in challenge conditions than in the control condition. Moreover, we hypothesised that the relationship of 2D:4D and HGS under challenge would be independent of other covariates of strength, including body mass, T, C, aggression and personality.

2. Methods

2.1. Participants

Participants were recruited from students and staff of two UK universities. Eighty-nine healthy men participated in the study, 87% of them were Caucasians, 11% Mixed Race, 1% Black and 1% Asian. The study received approval from the University Ethics Committee.

2.2. Protocols

An experimental study was undertaken using a crossover design [12,26]. The participants visited the laboratory on two separate occasions (with at least 7 days separating each visit) to complete an experimental treatment with challenge (video with rugby tackles) and control session (blank screen). All sessions took place between the hours of 9 am and 6 pm, with subsequent assessments made at the same time of day for each individual. On arrival at the testing facility, each participant sat and remained quiet for a period of 10 min while completing the consent forms and other documentation. The first saliva sample was collected immediately after the 10 min seated period. The participant was then either assigned to the challenge condition or the control condition. Both conditions had a duration of 4 min. Participants viewed the aggressive video or blank screen without any sound on an individual screen. To assess the effectiveness of the aggressive video, each participant was asked: "To what extent has physical aggression been shown in the video?" and "How aggressive does this video look in general?" Both questions were scored out of 100 for effectiveness (0 = not effective; 100 = highly effective). The mean for the former question was 84.71 ± 14.98 and for the latter question it was 80.06 ± 16.28.

After viewing the aggressive video or control, the participants completed two questionnaires: the Ten Item Personality Measure or TIPI [36] and the Buss-Perry Aggression Questionnaire or BPAQ [37]. A second saliva sample was collected 15 min after exposure to the condition. Previous research has demonstrated that concentrations of salivary T peak 15 min after the physical stimulus [27]. This collection timeframe is common in studies of this nature [26]. The participant then performed the HGS test with the dynamometer (Takei Kiki Kogyo grip dynamometer, Japan). Two measurements of maximum strength were recorded for the dominant hand (determined as the hand used to write with) and the mean value recorded. The testing procedure was repeated after a period of approximately one week, when the participant was exposed to whichever condition they had not previously experienced.

2.3. 2D:4D assessment

At the completion of the first condition, direct measurements of the 2nd (index) and 4th (ring) fingers from a mid-point on the ventral crease proximal to the palm to the tip of the finger were taken twice using digital callipers with 0.01 mm precision (Digimatic calliper, 500-196 series, Mitutoyo Corporation, Japan); for the protocol see [38]. The measurements were taken from both the left and the right hands and first and second 2D:4D was calculated (2D/4D) for each hand.

2.4. Saliva collection and hormone analysis

Approximately 2 mL of saliva were collected by passive drool in sterile polypropylene vials over a period of 2 min. The samples were subsequently stored at −80 °C until assay. After thawing they were centrifuged (1500 × *g* for 10 min) to remove precipitated mucins and other particulate matter, and the clear undiluted saliva samples were analysed for T and C in duplicate using enzyme immunoassay commercial kits (Testosterone No. 1-2402; Cortisol No. 1-3002, Salimetrics LLC, USA), and according to the manufacturers' guidelines [39,40]. Assay analytical sensitivity was 1.0 pg/mL for T and 0.007 μg/dL for C. The intra-assay coefficient of variation was 6.21% and 7.02% and inter-assay coefficient of variation was 6.57% and 8.49%, for T and C, respectively.

2.5. Statistical analysis

The data were analysed using paired *t*-tests, zero-order Pearson correlation coefficients, linear regressions and multiple regressions. With regard to the latter, independent variables were forced simultaneously into the analysis and slope (*b*), SE, and standardised regression coefficients (beta) reported. The level of significance was set at $p < 0.05$.

3. Results

3.1. Sample

The total sample comprised 89 men. However, numbers varied across traits due to non-attendance for the second visit and errors in some of the hormonal analyses.

3.2. Repeatability

For HGS there was high and significant repeatability (intra-class correlation coefficients, ICC's) for the first and second test (after control: $n = 87$, 1st test 39.10 ± 7.69 kg, 2nd test 37.16 ± 8.07, ICC = 0.81, $F = 9.47$, $p < 0.0001$; after challenge: $n = 83$, 1st test 40.91 ± 7.90 kg, 2nd test 39.03 ± 7.72 kg, ICC = 0.87, $F = 14.81$, $p < 0.0001$). Therefore, we calculated mean HGS for the control and video condition and used these in all subsequent analyses.

Both left and right hand 2D:4D showed high and significant ICC's for the first and second measurements (left 2D:4D, ICC = 0.90, $F = 18.98$, $p < 0.0001$; right 2D:4D, ICC = 0.99, $F = 143.87$, $p < 0.0001$). Mean left 2D:4D and right 2D:4D were calculated and found to be significantly correlated ($n = 89$, $r = 0.62$, $p < 0.0001$). Thus, we used the means for left and right 2D:4D in all subsequent tests.

3.3. Descriptive statistics

Of the 89 participants, there were 77 who described themselves as white and 12 of mixed and other ethnicities. Mean 2D:4D did not significantly differ between the two groups (left 2D:4D: white = 0.965 ± 0.032, other = 0.967 ± 0.026, $t = 0.22$, $p = 0.83$; right 2D:4D: white = 0.970 ± 0.031, other = 0.963 ± 0.027, $t = 0.71$, $p = 0.48$). The descriptive statistics for the sample were as follows: age = 23.51 ± 6.27 years; height = 1.80 ± 0.61 m, body mass = 79.00 ± 11.68 kg, BMI = 24.47 ± 3.14 kg·m^2, left 2D:4D 0.965 ± 0.031, right 2D:4D = 0.969 ± 0.031.

3.4. Relationships between 2D:4D and HGS

Mean HGS was higher in the challenge condition than in the control condition and the difference was strongly significant (challenge 39.91 ± 7.60 kg, SE = 0.84; control 38.23 ± 7.55 kg, SE = 0.85, $n = 81$, paired t-test x–$y = 1.69 \pm 3.29$, SE = 0.37, 95% confidence interval of the difference = lower 0.96, upper 2.41, DF = 80, $t = 4.61$, $p < 0.0001$). These differences were also present in the first and second trials of HGS (Fig. 1). The focus of our study was the relationship between 2D:4D in challenge and control conditions. We found a significant negative zero order correlation between left 2D:4D (but not right 2D:4D) and mean HGS in the challenge condition ($p = 0.03$). There were no significant correlations for right 2D:4D (Table 1). Note, it is inappropriate to correct for multiple tests across these four correlations as left and right 2D:4D are not independent from one another (Fig. 2).

3.5. Changes in means in the challenge and control conditions

In comparison to the control means there were significant changes in the challenge conditions for some variables. The magnitude of these changes was not as great as the changes observed for HGS (Table 2). However, our focus here was to determine which variables did not show evidence of change in order that they may be excluded from further analysis.

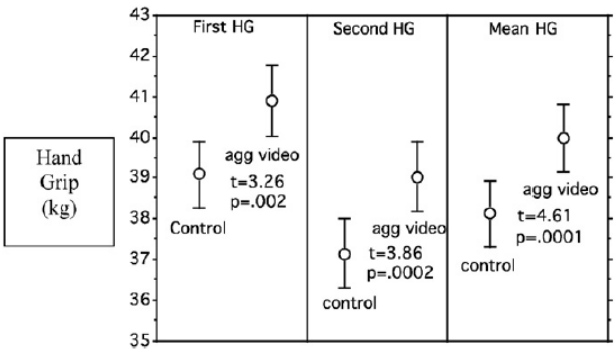

Fig. 1. Means and SE for hand grip strength (HG; kg), for first (first HG) and second (second HG) trials in the control condition and the aggressive video condition. Overall mean HGS for the two trials for the control and video condition are also shown.

Table 1
Correlations (product-moment) between 2D:4D (left and right hand) and hand-grip strength in the challenge and control conditions.

Condition	Left 2D:4D			Right 2D:4D		
	n	r	p	n	r	p
Challenge	83	−0.23	0.03	83	−0.004	0.97
Control	87	−0.18	0.10	87	0.02	0.84

With regard to scores on the BPAQ, scores for verbal aggression, anger and hostility showed no significant differences in the challenge and control conditions (verbal aggression $p = 0.13$; anger $p = 0.07$; hostility $p = 0.27$). Physical aggression was significantly greater after the challenge compared to after the control ($p = 0.04$).

With regard to the Big Five personality dimensions, there were no significant differences between the challenge and control condition in four traits (extraversion $p = 0.53$), agreeableness ($p = 0.83$); conscientiousness ($p = 0.63$); openness ($p = 0.27$). The one exception was emotional stability which was lower after the challenge compared to after the control ($p = 0.03$).

With regard to hormonal changes, mean T after the challenge was significantly greater than mean T after the control ($p = 0.04$). However, C concentration after the challenge did not differ from that after the control ($p = 0.82$).

It is to be noted that correction for multiple tests over Table 2 would result in loss of significance for physical aggression, emotional stability and T. However, we emphasise that these tests were performed in order to exclude from further analysis those variables that showed evidence of no change across the conditions. These stable variables included verbal aggression, anger and hostility (from the BPAQ); extraversion, agreeableness, conscientiousness and openness (from the Big Five); and cortisol.

3.6. Multivariate correlations with handgrip strength

We performed two multiple regressions with HGS as dependent variable in the control or challenge condition. For each regression, the independent variables included all "fixed" variables (i.e. left 2D:4D, right 2D:4D, BMI and age) and variables that showed some evidence of changes in the challenge condition in comparison to the control

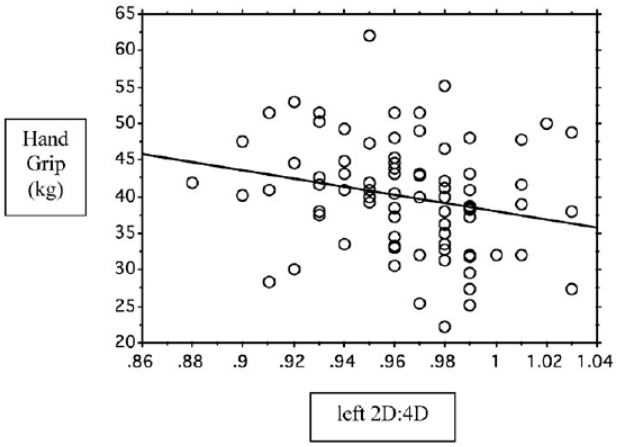

Fig. 2. The relationship between left 2D:4D and hand grip strength in the aggressive video condition.

Table 2
Means, SD's, SE's and paired samples tests for eleven traits in the challenge and control conditions.

Trait	Mean	*n*	SD	SE	*t*	*p*
Buss-Perry Phys. Aggression						
Challenge	25.48	81	7.73	0.86	2.12	0.04
Control	24.46	81	7.18	0.80		
Verb. Aggression						
Challenge	15.72	81	4.36	0.49	1.54	0.13
Control	16.58	81	5.36	0.60		
Anger						
Challenge	17.36	81	5.68	0.63	1.87	0.07
Control	16.58	81	5.36	0.60		
Hostility						
Challenge	19.75	81	5.81	0.65	1.12	0.27
Control	19.27	81	5.88	0.65		
TIPI Extraversion						
Challenge	8.91	81	2.95	0.33	0.63	0.53
Control	9.05	81	3.02	0.34		
Agreeableness						
Challenge	8.51	81	2.48	0.28	0.21	0.83
Control	8.54	81	2.41	0.27		
Conscientiousness						
Challenge	10.30	81	2.72	0.30	0.48	0.63
Control	10.38	81	2.77	0.31		
Emot. Stability						
Challenge	10.10	81	2.41	0.27	2.18	0.03
Control	10.52	81	2.32	0.26		
Openness						
Challenge	10.57	81	2.23	0.25	1.10	0.27
Control	10.78	81	2.10	0.23		
Testosterone						
Challenge	206.40	78	64.55	7.30	2.08	0.04
Control	192.60	78	53.68	6.08		
Cortisol						
Challenge	0.31	77	0.21	0.02	0.22	0.82
Control	0.32	77	0.25	0.03		

(i.e. physical aggression, emotional stability and T). Therefore, there were seven independent variables (Table 2).

For the control condition the overall model correlated significantly with HGS ($n = 78$, $r = 0.56$, $r^2 = 0.31$, $p = 0.0004$). There was a significant positive correlation between HGS and BMI (beta = 0.21, $p = 0.049$), physical aggression (beta = 0.25, $p = 0.03$) and emotional stability (beta = 0.24, $p = 0.02$). All other traits were non-significant (Table 3).

For the challenge condition, the overall model correlated significantly with HGS ($n = 77$, $r = 0.56$, $r^2 = 0.31$, $p = 0.0004$). With regard to the independent variables, left 2D:4D showed a significant negative correlation (beta = −0.39, $p = 0.005$) and emotional stability a significant positive correlation (beta = 0.24, $p = 0.02$) with HGS. The remaining traits were non-significant.

4. Discussion

We have found that, in comparison with the control condition, HGS increased after viewing an aggressive video. Therefore, the data support our prediction that strength-related changes occur in men during conditions of challenge. Left 2D:4D (but not right 2D:4D) correlated negatively with HGS in the challenge condition but in the control condition neither left nor right 2D:4D were significantly related to 2D:4D. This supports our prediction that 2D:4D is negatively correlated with HGS in challenge conditions. In this regard, it is relevant to note that in sports-related associations left or right 2D:4D have been reported

Table 3
Multiple regression analyses for dependent variables hand grip strength in the control and in the challenge condition. There were seven independent variables: left 2D:4D; right 2D:4D; age; BMI; Buss-Perry Physical Aggression Score; TIPI Emotional Stability Score; and Testosterone.

Trait	*b*	SE	St. Coeff.	*t*	*p*
Control condition					
Left 2D:4D	−56.46	32.88	−0.23	1.72	0.09
Right 2D:4D	42.19	32.83	0.17	1.29	0.20
Age	0.31	0.20	0.17	1.54	0.13
BMI	0.53	0.26	0.21	2.00	0.049
B-P Physical Aggression	0.27	0.12	0.25	2.29	0.03
TIPI Emotional Stability	0.79	0.34	0.24	2.34	0.02
Testosterone	−0.01	0.02	−0.07	0.66	0.51
Challenge condition					
Left 2D:4D	−93.84	32.55	−0.39	2.88	0.005
Right 2D:4D	60.48	33.09	0.25	1.83	0.07
Age	0.19	0.20	0.10	0.98	0.33
BMI	0.51	0.26	0.21	1.96	0.06
B-P Physical Aggression	0.20	0.11	0.19	1.75	0.08
TIPI Emotional Stability	0.76	0.33	0.24	2.32	0.02
Testosterone	−0.01	0.01	−0.11	1.07	0.29

as significant predictors of strength-related disciplines and one hand does not outperform the other [2]. Our finding of no significant associations between 2D:4D and HGS in the absence of aggressive stimuli supports our suggestion that aspects of male-male aggressive interaction should be controlled for in studies of 2D:4D and strength.

In comparison to the control condition, we found some evidence in the challenge condition for changes in physical aggression and T (increases) and emotional stability (reduction). Therefore, we controlled for these three variables in subsequent multiple regression tests. Two multiple regressions were performed (for the control and challenge conditions). The dependent variable was HGS and there were seven independent variables, four of which were "fixed" across conditions (right and left 2D:4D; BMI, age) and three "non-fixed" (physical aggression, emotional stability and T). In the control condition there were significant positive associations between HGS and BMI (beta = 0.21), physical aggression (beta = 0.25), and emotional stability (beta = 0.24). There were no significant associations with HGS and 2D:4D. In the Challenge condition, there were significant associations for left 2D:4D with beta = −0.39 (but not right 2D:4D), and emotional stability (beta = 0.24). Thus, our findings in the multiple regression tests support our predictions that 2D:4D is a negative correlate of strength in conditions of challenge. That is, associations between 2D:4D and strength are weaker if there is no control for male:male challenge behaviour.

Our findings emphasise the importance of investigating associations between traits in ecologically relevant situations. Strength is sexually dimorphic such that men tend to be stronger than women, and strength is important to men in male-male competitive situations [30]. These include challenging situations, such as aggressive encounters, but also competitive sports. In such situations, it may be advantageous to increase one's levels of strength, T and aggression. Therefore, it is expected that, in the context of a challenge, we would find strength, T and aggression to be inter-related. How does competition-induced increases in strength, T and aggression relate to 2D:4D? There is evidence that 2D:4D is negatively related to prenatal T and positively related to prenatal E [38,41]. Low 2D:4D may also be a marker for challenge-induced changes in T and aggression and to sensitivity to short-term changes in T. Thus, men with low 2D:4D and low right-left 2D:4D tend to produce high levels of T and high T/C ratios when challenged with intense exercise and/or aggressive stimuli [12,25]. Correlations between 2D:4D and aggression increase from non-significant levels to significance after exposure to aggressive stimuli [29,35]. Moreover, 2D:4D modulates the

effect of exogenous T application on empathy, moral judgements and co-operation [42–45].

In conclusion, we find that in non-challenging conditions, 2D:4D in men is weakly and non-significantly related to strength as measured by HGS. In such "baseline" situations, it is likely that some studies will find correlations between 2D:4D and strength while others will not. This is because some participants may have recently encountered challenge-conditions while others will have not. However, when there are controls for context and participants are challenged, 2D:4D is likely to show a significant negative correlation with strength. Our results indicate that this association is independent of body mass, T, C, aggression and personality.

Conflicts of interest

The authors have no conflicts of interest regarding the material presented in this paper.

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CAPITULO 5 – ESTUDO 3

Digit ratio (2D:4D) predicts performance in junior tennis players

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Digit ratio (2D:4D) predicts performance in junior tennis players

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Abstract

A low digit ratio (2D:4D), a putative marker for higher prenatal androgen action, is related to performance sports. Here we show that low 2D:4D was associated in 36% with tennis performance, in 64 male junior tennis players. The negative relationship with 2D:4D and hand grip strength ($r = -0.450$, $p < 0.01$) and with self-confidence ($r = -0.262$, $p < 0.05$) suggests that there are psychological and physical aspects from prenatal androgen action and tennis performance. There were no associations with 2D:4D and salivary testosterone or cortisol responsiveness when they were physically challenged. In conclusion, prenatal androgenization, as assessed by digit ratio (2D:4D), predicts performance in junior tennis players, suggesting that 2D:4D ratio could be an additional tool in talent identification and development of young tennis players.

Introduction

The ratio of the length of the second (index) to the forth (ring) finger (2D:4D) is a sexually dimorphic trait in which males tend to have lower 2D:4D mean in comparison to females. It is negatively related to prenatal testosterone (PT) and positively related to prenatal oestrogen (PE) (J T Manning et al., 1998). Assuming that the PT and PE balance are thought to have a permanent "organising" effect on the developing foetus which underpins some characteristics observed in high sporting performance, 2D:4D ratio might be an indicator of sports success. In fact, several studies found 2D:4D ratio negatively related to performance for both men and women in a range of sports (Hönekopp & Schuster, 2010).

The relationship between 2D:4D ratio and athletes' individual performance was seen in several sports. For example, a positive correlation between 2D:4D and race time in women rowing, i.e. females with smaller 2D:4Ds rowed substantially faster (Hull et al., 2014). In Japanese professional men sumo wrestlers, 2D:4D was negative associated with ranks and percentage of wins (Tamiya et al., 2012). In men surfers, 2D:4D explained about 25% of the variance in performance (L. P. Kilduff et al., 2011). The association of 2D:4D with performance was also observed in team sports such as football (John T Manning & Taylor, 2001) and rugby (Bennett et al., 2010). However, it is not easy to have a reliable measure of

individual performance in team sports, since each athletes' performance depends strongly on the squad and also on their interactions with the coach and audience, entailing some confusing variables.

Although there are evidence associating 2D:4D and sports success, we do not know which sports-related variables are influenced by prenatal androgenization and predicted by 2D:4D ratio. Some evidence point to strength, which can be assessed by different protocols. For example, a low 2D:4D ratio has been found to be associated with high handgrip strength (HGS) in adults and older people worldwide (Fink et al., 2006; Halil et al., 2013; Hone & McCullough, 2012; Zhao et al., 2012, 2013), and in boys from the UK (Ranson et al., 2015). Manning et al. (2007) suggested that that prenatal T is also important in determining efficiency in aerobic exercise and that 2D:4D ratio explained about 25% of endurance running in boys. Even significant, the associations between 2D:4D ratio and sprinting speed were much weaker than those reported for endurance running, suggesting that 2D:4D is a relatively weak predictor of velocity and a stronger predictor of efficiency in aerobic exercise in boys (J T Manning & Hill, 2009). High maximal oxygen uptake (VO2max), high velocity at VO2max, and high maximum lactate concentration in a sample of teenage boys were all associated with 2D:4D, suggesting that individual variation in VO2max is one underlying factor that could link digit ratio and performance in sport (Hill et al., 2012).

Other aspects that may contribute to sport performance include the hormonal change in response to physical and psychological challenge. In that regard, it has been shown that low right–left 2D:4D is a predictive marker of free testosterone responsiveness when trained men are physically challenged (L. Kilduff et al., 2013), although digit ratio are not associated with adult sex hormone levels in a normal population (Hönekopp, Bartholdt, Beier, & Liebert, 2007). In addition, abilities as spatial orientation and mental rotation, known to be influenced by prenatal steroids, may contribute with sports performance. Csathó et al. (2001) demonstrated that female university students with lower 2D:4D ratio showed a better cue learning effectiveness and better spatial recall during a real maze task. Digit ratio was also negatively correlated with mental rotation task score in men but not women, in three independent studies from Sweden/London, Hungary and Liverpool (Sanders et al., 2005). Furthermore, several psychological variables relevant to sport (mental toughness, optimism, goal orientations, coping strategies and hostility), were suggested to be associated to 2D:4D ratio (Golby & Meggs, 2011).

Tennis is an individual sport that requires speed, endurance, power and strength for quick starts and stops; visuospatial skills for repetitive overhead motions; and strong psychological conditions to oscillate randomly from brief periods of maximal or near maximal work to longer periods of moderate and low intensity activity (Fernandez et al., 2006). Because of that, tennis offers to science, easier understanding of player performance than team sports, since the match result depends on player's performance against their opponent, without a time to end, and the match is decided directly by interaction "male-male fighting". External effects during the match are minimal on player's performance since not even the coach can speak to the player during the match and the audience can only celebrate when the match is not on. Regardless being considered a good sport to explore the relationships between 2D:4D ratio with performance and sport-related traits (Lees, 2003) there is only a single study that investigated 2D:4D ratio in tennis, showing that elite and collegiate tennis players have lower 2D:4D than non-athletes, however no individual association to performance was analysed (Hsu et al., 2015).

Tennis, as well as some other sports, requires an early beginning, with boys starting to practice as young as 6 years old. Therefore, would be helpful to have an indicator of prenatal androgenization, as suggested by Kilduff et al. (2011) to be used as an additional tool in talent identification. The 2D:4D has this potential since it is determined during gestational age (Malas, Dogan, Evcil, & Desdicioglu, 2006) and remains stable throughout childhood and puberty (Trivers, Manning, & Jacobson, 2006). Therefore, this study was designed to try and answer some questions related to tennis performance:1) Is it possible to associate individually 2D:4D with performance? If so, what are some of the components associated with a higher performance? If present is the association between 2D:4D with performance evident from younger categories? In attempt to answer those questions, we tested association between 2D:4D with a) performance, b) testosterone and cortisol changes induced by physical challenge, c) isometric and explosive muscular strength, and d) mental toughness.

Methods

Participants and Tennis Performance

The sample consisted of 64 male tennis players. In average our sample was training 12.9 ± 5.9 hours a week and began to have tennis classes at 7.6 ± 2.6 years old. We deliberated invited participants aged between 11 and 18 years, to provide a sample from all ranked age group from the regional federation (Parana Tennis Federation FPT). We had 21 under twelve (U12), 14 under fourteen (U14), 12 under sixteen (U16) and 10 under eighteen (U18) participants. This sample represents about 56% of the total tennis players ranked at FPT, and the proportion from the total number of athletes per category were 59% (U12), 58% (U14), 61% (U16) and 43% (U18). Fifty-four of the participants (85%) expressed the desire to be a professional tennis player. The average for body weight was 55.9±14.3 kg and for height 1.67±0.13 m, with most of them being right hand (57/64; 89%), and 7 tennis players were left hand (11%).

As participant's tennis performance score, we used information available on the database of the official website for the FPT (http://www.fpt.com.br/Ranking), which included the individual participant history of matches wins divided by the total number of matches of the last five years (2011-2015) or for their career, when they had less than five years in official competition. For the performance index a total of 3680 matches with an average of 63 ± 41 matches per athlete on each respective category (ranging from 11 to 190 matches per player). The individual performance index ranged from 0.05 to 0.84.

Experimental design

This protocol was undertaken before a daily training section (at 14:00), on player's training place in two subsequent days (Figure 1), in the morning all players went to school. First day, the participants were informed and sign the consent form, they carry out an anamnesis, anthropometric and digit ratios measures. On next day, after a brief demonstration and verbal instructions about tests, they provide the first saliva sample and performed handgrip (HGS) and Standing Long Jump test (SLJ). Afterwards, they completed the Psychological Performance Inventory (PPI), and a second saliva sample was collected 15 minutes later of long jump test, to coincide with expected testosterone changes in this fluid (B. T. Crewther, Kilduff, Finn, Scott, & Cook, 2016). All protocols were approved by the Ethics Committee for the Protection of Human Subjects from Federal University of Paraná CEP/SD (521.630) and for testing young people, we had prior consent from parents and coaches.

Test protocols

Standing Long Jump (SLJ). The participant stood behind the starting line, with feet together, and pushed off vigorously and jumped forward as far as possible. The distance was measured from the take-off line to the point where the back of the heel nearest to the take-off line lands. The test was repeated twice, and the best score (in cm) was retained (Castro-Piñero et al., 2010).

Handgrip strength (HGS). Handgrip strength was measured using a standard adjustable handle analogue handgrip dynamometer (Takei Scientific Instruments, Japan). If necessary, the dynamometer was adjusted according to the child's hand (España-Romero et al., 2008). It was measured with the subject in a standing position with the shoulder adducted and neutrally rotated and arms parallel but not in contact with the body. The participants were asked to squeeze the handle for a maximum of 3–5 seconds. Two trials were allowed for the dominant limb and the best score recorded (kg) (Ramírez-Vélez, Rodrigues-Bezerra, Correa-Bautista, Izquierdo, & Lobelo, 2015).

Strength Normalisation for Body Size (Allometry). Body size is an important factor that affects muscle strength, especially in young people, were maturational stages are strongly associated with anthropometric variables (Medeiros et al., 2014). We used the normalisation method based on the allometric approach to assess index of strength independent of body size as equation 1, in which, F = muscle strength, m = body mass (kg) and b= is the allometric parameter, i.e. b from linear regression with body mass (kg) as independent variable and HGS or SLJ recorded as dependent variable (S. Jaric, Ugarkovic, & Kukolj, 2002; Slobodan Jaric, 2002).

$$F_{nor} = \frac{m^b}{F}$$

Equation 1 – Allometric normalization for strength

Psychological Performance Inventory (PPI; (Loehr, 1986)**.** It is a self-report inventory, with 42 items on a 5- point Likert scale, where 1=Almost always, and 5=Almost never. There are seven subscales to measure factors that reflect mental toughness in an athlete, each subscale consisted of six items, i.e. self-confidence (e.g., "I lose my confidence very quickly"), negative energy control (e.g., "I get nervous or afraid in competition"), attention control (e.g., "I can clear interfering emotion quickly and regain my focus"),

visualization and imagery control level (e.g., “Before competition, I picture myself performing perfectly”), motivation (e.g. I am highly motivated to play my best), positive energy control (e.g., “I can keep strong positive emotion flowing during competition”), and attitude control (e.g., “I am a positive thinker during competition”). The responses from PPI can be scored by each subscale (0 – 30) and total (0-210). We used a translated and validated version for Brazilian athletes (Mahl & Vasconcelos, 2007).

Digit ratio (2D:4D) assessment

Measuring procedure. Direct measurements of the 2nd (index) and 4th (ring) fingers, from a mid-point on the ventral crease proximal to the palm to the tip of the finger, were taken twice using digital callipers with 0.01 mm precision (Digimatic calliper, Mitutoyo Corporation, Japan) (J T Manning et al., 1998).

Repeatability study. There was high and significant repeatability (intra-class correlation coefficients, ICC’s) for both right and left hand 2D:4D for the first and second measurements (right 2D:4D, ICC=0.952, F=41.046, p =0.000; left 2D:4D, ICC = 0.966, F = 57.656, p = 0.000). Mean left 2D:4D and right 2D:4D were calculated and found to be significantly correlated (n=64, r=0.708, p =0.000).

Saliva collection and hormone analysis

Approximately 2 ml of saliva, over a period of 2 min, were collected by passive drool in clean tubes and stored at −20 °C until assay. After thawing they were centrifuged (1500 ×g for 10 min) to remove precipitated mucins and other particulate matter, and the clear undiluted saliva samples were analysed for T and C in duplicate by ELISA, with analytical sensitivity 20.0 pg/mL for T and 0.04 μg/dL for C. The antibody against testosterone, cortisol and the respective HRP-conjugate were obtained from Coralie Munro at the University of California (Davis, CA, USA). The intra-assay and inter-assay coefficient of variation was respectively, 1.6% and 8.7% for Testosterone and, 1.4% and 1.6%, for Cortisol.

Statistical analysis

Normality was confirmed using Kolmogorov–Smirnov normality test and the data were analysed using paired t-tests, bivariate Pearson’s correlations, linear regressions and

multiple regressions, in which, independent variables were forced simultaneously into the analysis and slope (b), SE, and standardised regression coefficients (beta). Analysis of Variance (ANOVA) was used to test cortisol and testosterone between age group. Hormones levels (before and after) were natural log transformed to fit the assumptions of the analyses (normality of residuals and equality of variances). The level of significance was set at $p < 0.05$ and all statistical analyses were carried out by SPSS 23.0.

Results

Descriptive Statistics and Pearson's Correlation

There was no difference in paired t test for right and left 2D:4D (x-y = 0.004 ± 0.02, t = 1.81 p = 0.07), the mean for right 2D:4D was 0.959 ± 0.03 and for left 2D:4D was 0.955 ± 0.03. Descriptive statistics and Pearson's correlations with tennis performance are summarized in *Table 1*. We found a negative correlation with right (Figure 2) and left (Figure 3) digit ratios and positive correlation with expertise, handgrip strength and self-confidence. There were no significant correlations for C, T and other traits of PPI. The case number varied across some traits (T change, C change and PPI) due to non-complete-response on PPI and some inadequate saliva conditions for assay. We checked relationships with digit ratio (2D:4D) and HSG, SLJ, C, T and PPI (Table 2). There were negative correlations between HGS and SLJ for both left and right 2D:4D, and self-confidence was negative correlated only with left 2D:4D. Additionally, we tested the variance of testosterone and cortisol across age group (Table 3). Note that for the mean of all groups T increased 13%, but within each age group, only for U16 there was a significant increase of 23%. Comparing between groups, T becomes higher as the group grows older but this was significant only comparing U12 and others.

Multivariate Associations with performance

We performed a multiple regression including the variables that in Pearson's correlations were significant with tennis performance. For each regression, the independent variables were, left (2D:4D), right 2D:4D, HGS and expertise. The overall model correlated significantly with tennis performance ($r = 0.74$, $r^2 = 0.55$, $F = 17.13$, $p = 0.000$). With regard to the independent variables, left 2D:4D showed a significant negative correlation (beta= −0.47,

p= 0.001) and expertise expressed positive correlation (beta= 0.42, p= 0.000). The right 2D:4D was significant in a linear regression (r= 0.43, r^2= 0.17 p= 0.000), also HGS (r= 0.43, r^2= 0.17 p= 0.001) but both were non-significant when forced simultaneously into the multivariate analysis (Table 4).

Discussion

We found that right 2D:4D ratio was associated in 17% and left 2D:4D ratio in 35% with junior tennis performance. In the multiple regression analysis, controlling expertise in years, left 2D:4D and expertise explained together about 52% of the performance. As far as we know, our study is the first to investigate the association between digit ratio (2D:4D) and tennis performance individually. The previous study by HSU et al. (2015) compared 2D:4D between groups (elite vs. collegiate vs. non-athletes) assuming that each group was representative of a different level of performance. Several other studies showed similar results associating 2D:4D ratios with individual performance in a range of sports. In surfing , for example, performance had an association of about 25% with right 2D:4D (L. P. Kilduff et al., 2011) and, in fencers, 2D:4D explained 12% of the Austrian female fencing ranking, although it was non-significant in males (Voracek et al., 2010). Also, in female rowers aging 12 to 30 years, the smaller the 2D:4D the faster the athletes were, although the relationships were weak to moderate (8-10%) for all females, moderate-to-strong (17-30%) for rowers aged more than 20 years, and weak (1-3%) for junior rowers under 20 years (Hull et al., 2014). All these evidences, including our study, seems to clearly indicate that prenatal androgenization effects, assessed by 2D:4D, are related to individual performance in sports.

Furthermore, we showed a significant negative relationship between left and right 2D:4D ratio with HGS (respectively for right 2D:4D, r= −0.37 and left 2D:4D r= −0.45, p=0.001). This evidence just confirmed previous studies where a low 2D:4D ratio was associated with high handgrip strength (HGS) in adults and older people worldwide (Fink et al., 2006; Halil et al., 2013; Hone & McCullough, 2012; Zhao et al., 2012, 2013), and in boys from the UK (Ranson et al., 2015). As expected, we found positive relationship with HGS and tennis performance (r=0.43 p=0.000) but it was not confirmed by the multiple regression analysis. Tennis specificities to strength are not exactly to HGS, but there previous evidences that HGS and tennis performance are associated (Bonato et al., 2015; Gallo-Salazar et al.,

2015; Girard & Millet, 2009). Nevertheless, handgrip strength is a good test to be used in assessment of young tennis players, since it is easy to measure, it is a good predictor of total muscle strength in children, adolescents and young adults, and can be easily adjusted for body mass with allometric equations (Wind, Takken, Helders, & Engelbert, 2010). Besides, HGS is sexually dimorphic, with men typically being stronger than women (Hoffman, Stauffer, & Jackson, 1979). The other test we used for muscle function assessment, the SLJ, was also negatively related with right and left 2D:4D (respectively $r= -0.29$ and $r= -0.30$, $p= 0.01$), however, we found no relationship between SLJ and tennis performance. We believe that does not mean explosive muscular strength is not important for tennis performance, but maybe SLJ test does not reflect tennis specificity (Filipčič, Pisk, & Filipčič, 2010; Munivrana, Filipčić, & Filipčić, 2015) or is not accurate measurement to see this relationship.

The psychological aspects are also very important to tennis performance and, interestingly, we found significant Person's correlations between self-confidence and left 2D:4D ($r= -0.26$ $p=0.02$) and with tennis performance ($r= 0.28$ $p=0.02$). A relationship between overconfidence and 2D:4D ratio (Neyse et al., 2016), especially overconfidence in motor skills in children (Da Silva et al., 2014) were previously reported after experimental observation. The overall results for mental toughness did not show any relationship with 2D:4D ratio or performance, even though Golby & Meggs (2011), have demonstrated by self-reported inventory an influence of prenatal androgenization in mental toughness and sports performance. Here we highlight that, we used a self-reported inventory, but psychological experimental observation could be more accurate.

Finally, we have found that the physical tests caused a T increase of 13% for the overall sample, but there was no relationship between the magnitude of the change with 2D:4D or tennis performance. When analysing the mean T mean levels, we found that, before the test, U12 boys had lower levels only when compared to U18, but after the physical tests, all the other groups had higher T levels than U12 boys. Previous data from adult male population in UK demonstrated increases T and HGS after a visual-challenge (5min video) stimuli and it was associated with left 2D:4D (Evaldo Ribeiro et al., 2016). Besides, 2D:4D ratio was the strongest predictor of a high increase of T levels in men under challenge (B. Crewther et al., 2015). In our study, perhaps because we were investigated T response in a young population, we could not find any relationship in T levels increase and 2D:4D ratio, suggesting that sexual maturation should be controlled when assessing responsiveness of the gonadal hormone axis. We cannot also exclude the possibility that our hormonal data had

have been influenced by other factors, since we did not control previous activities that could influence hormones levels e.g. physical activities in the morning before the tests, intensity of last training section and food ingestion before saliva collection.

In conclusion, prenatal androgenization, as assessed by digit ratio (2D:4D), predicts in 36% performance in junior tennis players, suggesting that 2D:4D ratio could be an additional tool in talent identification and development of young tennis players. Digit ratio was associated with isometric (HGS) and explosive (SLJ) muscular strength and self-confidence, and all of them (except SLJ) was associated with tennis performance, suggesting a link between those characteristics, prenatal androgenization and tennis performance. However, we still cannot answer which characteristics, from those influenced by prenatal androgenization, underlie tennis performance. Future studies should explore other aspects such as aerobic endurance, reaction time or visuospatial ability, as well as studies in female samples.

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Table 1– Descriptive Statistics and Pearson's Correlations (r) with tennis performance

Trait	N	Mean	SD	Min.	Max	r
Right 2D:4D	64	0.959	0.025	0.891	1.031	−0.433 **
Left 2D:4D	64	0.955	0.025	0.897	1.017	−0.600 **
Expertise (years)	64	6.8	2.71	2.21	12.19	0.543 **
Handgrip (kg)	64	34.5	11.46	19.0	62.0	0.428 **
Standing Long Jump (cm)	60	184	24	147	240	0.188
C change (after – before)	58	2%	37%	−68%	110%	−0.147
T change (after – before)	56	13%	64%	−47%	370%	−0.191
Mental toughness (PPI)	59	149.54	20.64	113.0	193.0	0.188
self-confidence	59	22.31	4.08	12	30	0.282 *
negative energy control	59	17.83	3.87	10	26	0.082
attention control	59	18.19	4.21	8	28	0.131
imagery control	59	21.31	3.57	14	29	0.201
motivation	59	24.61	3.85	11	30	0.111
positive energy control	59	23.92	3.65	13	30	0.111
attitude control	59	21.39	4.12	12	30	0.157

***** p< 0.01, * p< 0.05***

Table 2 –Pearson's Correlations (r) with Right and Left digit ratio (2D:4D)

Trait (n)	Right 2D:4D	Left 2D:4D
HGS (64)	−0.374**	−0.450**
SLJ (60)	−0.294*	−0.304*
C change (58)	0.326*	0.203
T change (56)	0.066	−0.138
Mental toughness (59)	−0.071	−0.170
***self-confidence* (59)**	−0.162	−0.262*

p< 0.01 *p<0.05

Table 3 - **T and C levels, ANOVA within after x before and between age groups**

Hormones	Cat.	N	Before	After
Cortisol (µg/dl)	All	59	0.49 ± 0.27	0.50 ± 0.24
	U12	21	0.47 ± 0.27	0.42 ± 0.18
	U14	19	0.41 ± 0.21	0.47 ± 0.18
	U16	11	0.56 ± 0.31	0.61 ± 0.35
	U18	8	0.65 ± 0.29	0.65 ± 0.28
Testosterone (pg/ml)	All	56	171.89 ± 114.48**	194.86 ± 121.71**
	U12	20	124.42 ± 92.06 [a]	127.71 ± 104.91[a]
	U14	19	162.09 ± 89.06 [a,b]	190.21 ±99.95[b]
	U16	10	216.03 ± 126.52* [a,b]	265.07 ±126.05* [b]
	U18	7	271.02 ± 151.54 [b]	299.06 ±105.59 [b]

**p<0.01, * p<0.05, a= U12<U18*, b= U12<U14, U16, U18*

Table 4 - Multiple regression analyses for dependent variable tennis performance.

Trait	b	SE	St. Coeff.	t	p
Right 2D:4D	−7.417	104.947	−0.009	−0.071	0.944
Left 2D:4D	−391.445	109.308	−0.472	−3.581	0.001
Expertise	3.370	0.759	0.420	4.443	0.000
Handgrip	13.678	17.238	0.082	0.793	0.431

Figure 1 - Saliva sampling procedures in the test design. Each black bar represents a saliva sample

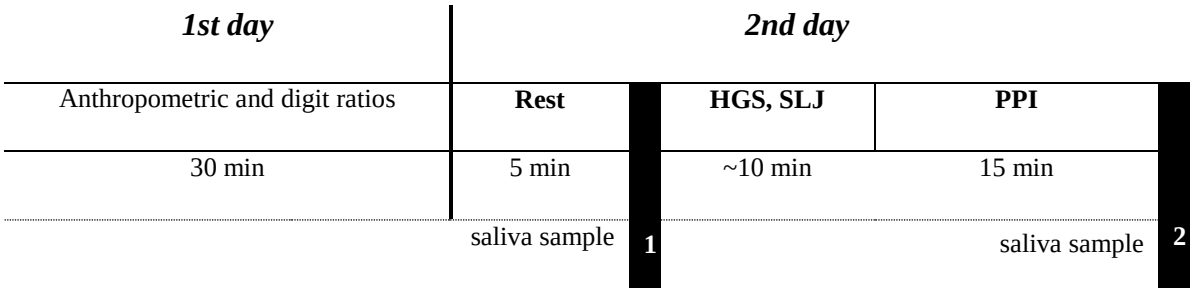


Figure 2 - Relationship with Right digit ratio (2D:4D) and tennis performance

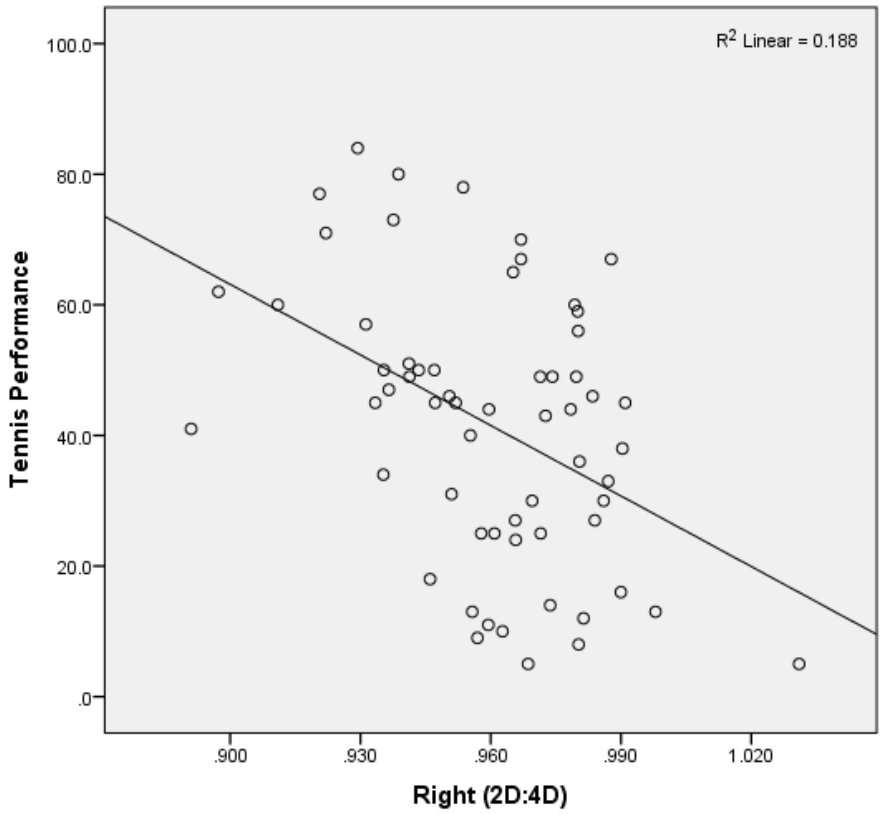
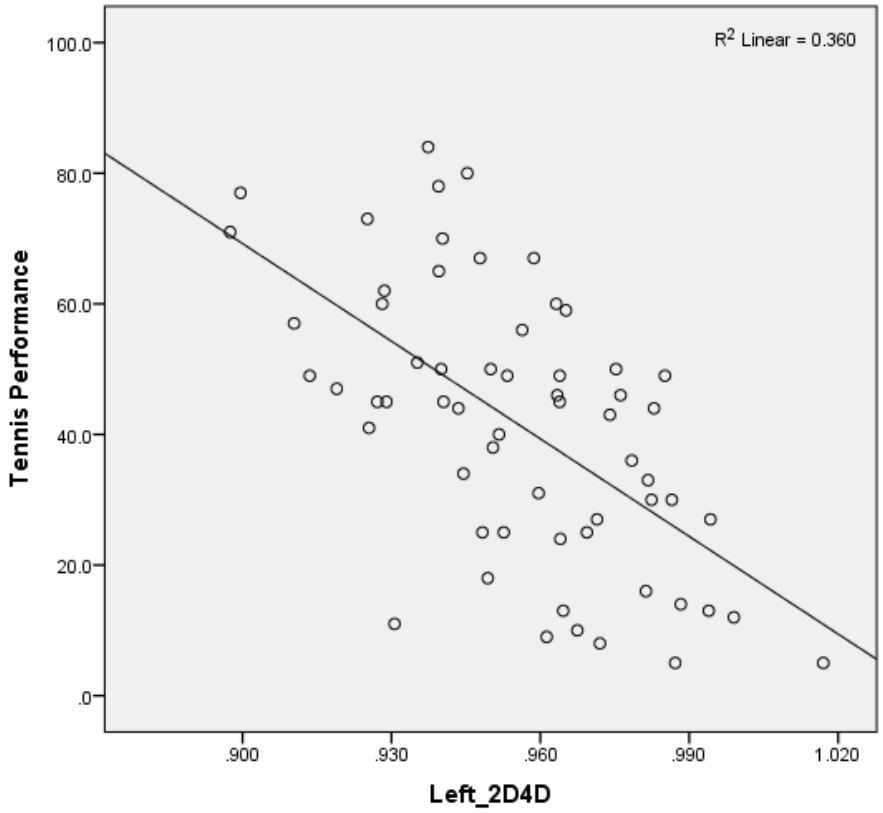


Figure 3 - Relationship with Left digit ratio (2D:4D) and tennis performance



CAPITULO 6 – CONCLUSÕES E CONSIDERAÇÕES FINAIS

Com base no nosso primeiro objetivo, que foi comparar a medida direta e indireta (por escâner ou fotocópia) e discutir sobre um possível efeito direcional no qual a medida direta da razão 2D:4D tende a ser maior que a medida indireta. Concluímos confirmando a existência do efeito direcional atrelado à forma que é mensurada a razão 2D:4D, no qual evidenciamos que a medida indireta tende a superestimar a androgenização pré-natal por apresentar médias de razão 2D:4D inferiores.

Acreditamos que a medida direta pode ser considerada a medida padrão para a razão 2D:4D, uma vez que obedece a premissa de que o avaliado permanece em posição anatômica. Conforme apresentamos na revisão de literatura, os ossos da mão (carpos metacarpos e falanges) são articulados em diversos segmentos e mantê-los em posição anatômica sugere que não há distorções de medidas causadas por movimentações entre os ossos da mão. Acreditamos que o viés de menores razão 2D:4D na medida indireta, se deva a dois fatores principais: primeiramente devido a posição da mão em pronação (palma da mão voltada para baixo), essa posição é o contrário da posição considerada anatômica, isso pode gerar movimentação entre os ossos do carpo e metacarpo principalmente, gerando provavelmente uma superestimação da medida do quarto dedo (anelar); o segundo ponto é que a medida de razão 2D:4D é uma medida de comprimento ósseo que medimos sobre a pele. Devido à pele ser um tecido mole, distorções podem ser causadas ao se pressionar a mão contra a plataforma de vidro do escâner ou fotocopiadora.

Apesar desse efeito direcional, consideramos que ambas as medidas são válidas e apresentam vantagens e desvantagens. A medida indireta possui algumas vantagens sobre a medida direta, por exemplo, a economia de tempo de coleta (tempo em que o participante passa com a mão imóvel); o escâner ou fotocópia gera registro da mão do participante, podendo ser conferido em caso de dúvidas quanto a medida anotada. Já na medida direta, a principal vantagem é realizada apenas com um paquímetro, extremamente portátil, dispensando equipamentos, como escâner, fotocopiadora e infraestrutura no local de coleta como tomadas elétricas e mesa.

Nosso segundo objetivo foi avaliar a produção de força muscular, liberação de testosterona, cortisol e aumento de agressividade de homens expostos a um vídeo contendo imagens de agressão no esporte (situação desafiadora) comparando com os mesmos em situação de controle. A principal consideração deste estudo foi que a situação chamada de desafiadora (vídeo com cenas agressivas no rúgbi) pode ser considerada um modulador no aumento de testosterona e aumento de força em pessoas com maior androgenização pré-natal. Estudos que visam investigar força ou concentrações hormonais, devem considerar o contexto em que o participante este exposto, antes e durante o experimento. Isto é, o ambiente (físico e psicológico) tem muita influência na ativação do sistema somático e endócrino. Ao se buscar observar efeitos de androgenização pré-natal em comportamentos ou componentes fisiológicos, é importante considerar que, os efeitos são modulados pela situação ao qual o indivíduo está exposto. Acreditamos que muitas falhas de replicação e contradições nas pesquisas com a razão 2D:4D, residem na falta de controle do método de medida e falta de controle da situação a que o indivíduo é exposto durante os testes.

Por fim, nosso terceiro objetivo foi avaliar a razão 2D:4D de tenistas infanto-juvenis e associar com o desempenho tenístico, força muscular, potência muscular de membros inferiores e resistência mental. Aqui, evidenciamos forte associação da razão 2D:4D com desempenho tenístico, indicando que existem efeitos da androgenização pré-natal que estão relacionados com o desempenho no tênis infanto-juvenil. Talvez estes efeitos podem já estar selecionando jovens atletas por meio de uma seleção natural (ex. relação êxito e evasão do esporte) onde os mais androgenizados no período pré-natal, por possuírem vantagens ao longo das competições infanto-juvenis seguem competindo, e os menos androgenizados desistem.

Por este motivo, acreditamos que a utilização da razão 2D:4D pode auxiliar treinadores sendo mais um indicador de desempenho nas baterias de testes físicos. Na literatura há um apelo de que essa medida seja utilizada na identificação e desenvolvimento de talentos. Nos interpretamos e expressamos esta questão, indicando que a razão 2D:4D pode sim ser medida auxiliar em compreender características e propensões do jovem atleta e com isso direcioná-lo no treinamento, conciliando as necessidades do esporte, principalmente em idades bem jovens ou

nos primeiros anos de treinamento, uma vez que as informações que a medida 2D:4D nos fornece, sobre efeitos da androgenização pré-natal em comportamentos e capacidades físicas, podem também ser observados simplesmente pelo acompanhamento do atleta ao longo dos anos.

Enfatizo que, de forma alguma, sou favorável ao uso de medidas para selecionar ou excluir atletas do esporte, embora algumas medidas possam parecer óbvias, como por exemplo a estatura, já que a alta estatura tem sido decisiva para o alto rendimento na maioria dos esportes. No entanto, nunca devemos deixar que testes e medidas interfiram na prática esportiva ou na esperança de uma criança em atingir o alto nível no esporte. As medidas são, sim, muito úteis e devem continuar a serem estudadas e descobertas, para auxiliar os jovens nesse longo caminho esportivo, o auxílio das medidas de detecção de talentos deve ser aproveitado para direcionar o treinamento e prática, jamais para seleção e exclusão.

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Anexo 1 – Termo de esclarecimento (UK)

PARTICIPANT INFORMATION

NAME OF RESEARCHER Evaldo Ribeiro

PROJECT TITLE Testosterone and aggression

1. What is the purpose of the project?

Previous research has indicated that the hormones testosterone and cortisol may be associated with certain aspects of personality in males. In this study we aim to measure prenatal testosterone exposure (via finger length ratio) and also circulating testosterone and cortisol via saliva. We will assess various personality characteristics associated with aggression before and after exposure to a neutral video, or an aggressive video.

2. Why have I been selected to take part and what are the exclusion criteria?

You are a heterosexual male aged over 18 have indicated you are interested in taking part.

Exclusion criteria includes:

A physical injury to your fingers which would render the measurement of their length inaccurate.

If you are taking any medication or have a medical condition that interferes with your hormone levels – specifically testosterone.

If you have undertaken any strenuous exercise 48 hours prior to your test session

3. What will I have to do?

You will be invited to take part in two sessions within Northumberland Building at City campus. There will be several tasks and activities during each visit including:

Visit 1

- Complete a demographic questionnaire covering general information about yourself.
- Have the fingers on both of your hands measured.
- Provide a grip-strength measure.
- Provide a sample of saliva by placing a small cotton swab in your mouth for 3 minutes and then placing it into a plastic tube. This can be conducted in private if you are embarrassed about doing this in front of the researcher.
- You will then be asked to watch a short video (approx. 4 minutes long). This will either be a neutral video which is designed not to trigger any emotional responses in you, or it will be a video containing scenes of contact aggression (rugby tackles) designed to influence your hormone levels. Note that this video does not depict any extreme violence (blood, major physical damage, or death) but if you become distressed at any point you can stop the video and withdraw from the study.
- Approximately 15 minutes after watching the video you will be asked to provide another saliva sample and answer some questionnaires relating to personality and mood.

Visit 2 (approximately 7 days later)

- Provide a grip-strength measure.
- Provide a sample of saliva by placing a small cotton swab in your mouth for 3 minutes and then placing it into a plastic tube. This can be conducted in private if you are embarrassed about doing this in front of the researcher.
- You will then be asked to watch a short video (approx. 4 minutes long). This will be the opposite video to the one you watched previously.
- Approximately 15 minutes after watching the video you will be asked to provide another saliva sample and answer some questionnaires relating to personality and mood.
- Receive a debrief

We expect that taking part will take around 1 hour of your time on the first occasion, and then around 45 minutes on the second occasion.

All of these questionnaires and procedures have been approved by the Health and Life Sciences Ethics Committee and are administered/conducted by trained members of the research team who will strictly adhere to the relevant Risk Assessments.

4. Will my participation involve any physical discomfort?

The swabs used to collect your saliva can feel a bit uncomfortable in your mouth however; you will only have these in your mouth for about three minutes.

5. Will my participation involve any psychological discomfort or embarrassment?

The nature of the aggressive video might cause you some emotional distress as it is quite graphic. However, on the occasion that you have viewed the aggressive video you will be asked to view a calming video before leaving the lab. You can of course stop the aggressive video at any point and withdraw your participation.

Providing the saliva sample may cause some mild embarrassment, but you can do this in private if you wish.

All procedures have been risk assessed and have been rated as 'minor'.

6. Will I have to provide any bodily samples (i.e. blood, saliva)?

Yes, you will be asked to provide 4 saliva samples in total.

7. Will I receive any payment or remuneration?

No

8. How will confidentiality be assured?

Other than information on the consent forms, no personally identifying information will be gathered from you. Data will be held securely by Northumbria University. Consent forms will be stored separately from questionnaires thus ensuring that responses cannot be matched with your personal details other than by your assigned participant ID number. Furthermore, all final results are averaged across all participants and thus your own personal responses will not be discernible from other participant results.

9. How can I withdraw from the project?

If you wish to withdraw please email the researcher quoting your participant ID number (found at the top of the debrief sheet). Please note that the option to withdraw exists for one month following agreement to participation. This is because the identifying information you provided may have been removed from your data for analysis purposes. This means that it will not be possible to separate your data from the data of other participants and that we, therefore, cannot remove your data.

Researcher: evaldo.ribeiro@northumbria.ac.uk

10. If I require further information who should I contact and how?

For further information please contact:

Researcher: nick.neave@northumbria.ac.uk

If you have any concerns or worries concerning this research or if you wish to register a complaint, please direct it to the Department of Psychology Ethics Chair at the address below, or by Email: andriy.myachykov@northumbria.ac.uk.

The data collected in this study will be used for publication in scientific journals or presented at conferences. Any information and data gathered during this research study will only be available to the research team identified in the information sheet. Should the research be presented or published in any form, all data will be anonymous (i.e. your personal information or data will not be identifiable).

All identifiable paper records will be stored in a locked filing cabinet, accessible only to the research team and all electronic information will be stored on a password-protected computer. Data will be held in accordance with Northumbria Universities' guidelines and the Data protection act. It will be held for 3 years before being destroyed unless a publication results, in this case data will be held in accordance with the journal guidelines. During that time the data may be used by members of the research team for appropriate research questions, but at no point will your personal information or data be revealed.

This study and its protocol have received full ethical approval from the Department of Psychology Ethics Committee in accordance with the School of Life Sciences Ethics Committee. If you require confirmation of this please contact the Chair of this Committee, stating the title of the research project and the name of the researcher:

Dr. Andriy Myachykov,

Northumberland Building, Office 146

Northumbria University

Newcastle-upon-Tyne

NE1 8ST

Tel: +44 (0)191 2273158

Fax: +44 (0)191 2274515

Anexo 2 - Termo de consentimento (UK)

Faculty of Health & Life Sciences

CONSENT FOR TAKING PART IN A STUDY WHICH MIGHT CAUSE PSYCHOLOGICAL DISTRESS

Project Title: Testosterone and aggression

Principal Investigator: Evaldo Ribeiro

please tick or initial where applicable

I have carefully read and understood the Participant Information Sheet.	☐
I have had an opportunity to ask questions and discuss this study and I have received satisfactory answers.	☐
I understand I am free to withdraw from the study at any time, without having to give a reason for withdrawing, and without prejudice.	☐
I agree to take part in this study.	☐
I understand that by taking part in this study I may be exposed to situations that may generate some psychological distress that may become apparent during and/or after the study has finished. I accept the small risk of experiencing psychological distress as part of this research	☐
I would like to receive feedback on the overall results of the study at the email address given below. Email address……	☐

Signature of participant..... Date.....……. (NAME IN BLOCK LETTERS).....…….	
Signature of researcher..... Date.....…….. (NAME IN BLOCK LETTERS) EVALDO RIBEIRO	

Faculty of Health & Life Sciences

FOR USE WHEN TISSUE IS BEING REMOVED AND STORED

Principal Investigator: Evaldo Ribeiro

I agree that the following tissue or other bodily material may be taken and used for the study:

Tissue/Bodily material	Purpose	Removal Method
saliva	*for testosterone and cortisol analysis*	*Via salivettes*

I understand that if the material is required for use in any other way than that explained to me, then my consent to this will be specifically sought. I understand that I will not receive specific feedback from any assessment conducted on my samples, but should any kind of abnormality be discovered then the investigator will contact me.

I understand that the University may store this tissue in a Licensed Tissue Bank only for the duration of the study, it will then be destroyed.

Method of disposal:

Clinical Waste ☐

Other ☐

If other please specify.....

I consent to the University distributing this tissue to partners in this research study, outside of the University, for further testing (please tick the box if you agree). ☐

Signature of participant..... Date.....……..

Signature of researcher..... Date.....……..

Anexo 3 – Aprovação do comitê de ética da UFPR

UNIVERSIDADE FEDERAL DO PARANÁ - SETOR DE CIÊNCIAS DA SAÚDE/ SCS -

Plataforma Brasil

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Relação entre a razão 2D:4D (indicador de androgenização pré-natal), performance esportiva e comportamento competitivo em atletas de tênis infanto-juvenis

Pesquisador: Evaldo José Ferreira Ribeiro Junior
Área Temática:
Versão: 4
CAAE: 20894413.0.0000.0102
Instituição Proponente: Programa de Pós-graduação em Biologia Celular e Molecular
Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 521.630
Data da Relatoria: 05/02/2014

Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

Considerações Finais a critério do CEP:
O TCLE deverá conter duas vias, uma ficará com o pesquisador e uma cópia ficará com o participante da pesquisa, tanto o participante como o pesquisador deverão rubricar todas as páginas do TCLE, opondo assinaturas na última página do referido Termo (Carta Circular nº. 003/2011CONEP/CNS.

CURITIBA, 05 de Fevereiro de 2014

Assinador por:
Claudia Seely Rocco
(Coordenador)

Anexo 4 – Termo de consentimento da UFPR

MINISTÉRIO DA EDUCAÇÃO
UNIVERSIDADE FEDERAL DO PARANÁ
SETOR DE CIÊNCIAS BIOLÓGICAS
PÓS-GRADUAÇÃO EM BIOLOGIA CELULAR E MOLECULAR

UFPR Biológicas 75 anos

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO

a) Você esta sendo convidado a participar de um estudo intitulado "Relação entre a razão 2D:4D (indicador de androgenização pré-natal), performance esportiva e comportamento competitivo em atletas de tênis". É através das pesquisas que ocorrem os avanços importantes em todas as áreas, e sua participação é fundamental.
b) Este projeto tem como justificativa: identificar e compreender medidas que auxiliem na programação e escolha de treinamento esportivo.
c) O objetivo da pesquisa é identificar a relação da medida de comprimento dos dedos (2D:4D), indicadores hormonais, indicadores comportamentais e performance esportiva.
d) Alguns atletas serão selecionados para serem avaliados bimestralmente ao longo de um ano. Caso você seja selecionado para esse grupo da pesquisa, será convidado já no primeiro contato e tem a liberdade de se retirar da pesquisa a qualquer momento ao longo do ano.
e) Atletas não selecionados para o grupo de avaliações bimestral serão avaliados apenas uma vez.
f) Caso você participe da pesquisa, será realizada as seguintes medidas:
    a. Coleta de saliva para avaliar a concentração hormonal (testosterona e cortisol).
    b. Fotocopia da mão para medida de comprimento de dedo (androgenização pré-natal).
    c. Testes motores: corridas, saltos e lançamentos de bolas.
g) A coleta de saliva consiste em bochechar água para limpar a boca, colocar um algodão de alta absorção de saliva na cavidade bucal e permanecer por um minuto até encharcar, após isto devolver ao tudo plástico do kit de coleta. O tubo contém o algodão e é lacrado e
h) Os riscos que envolvem todas as coletas são: 1) sensibilidade alérgica à algodão. 2) ânsia momentânea, parará quando retirar o algodão da boca. 3) Risco de quedas durante execução de corridas e saltos.
i) A participação neste estudo é voluntária. Você tem a liberdade de recusar participação no estudo, assim como retirar seu consentimento a qualquer momento.
j) Os dados divulgados em publicações serão codificadas para que a confidencialidade seja mantida.
k) Está garantido seu acesso a todas as informações que você queira, antes, durante e depois do estudo.
l) Esta pesquisa não tem fins lucrativos. Você não pagará e não receberá qualquer valor em dinheiro pela sua participação no estudo.
m) O pesquisador responsável pelo estudo é o Doutorando em Biologia Celular e Molecular Evaldo José Ferreira Ribeiro Junior, telefones (41) 3361-1719 ou (41) 9147-4861, eribeirojr@hotmail.com. A pesquisa é orientada pela professora Dr. Rosana Nogueira de Morais (UFPR). Poderão ser contatados para esclarecer eventuais dúvidas no Laboratório de Fisiologia Endócrina (laboratório nº 111) no Centro Politécnico, Setor de Biológicas, Departamento de Fisiologia. Endereço: Av. Cel. Francisco H. dos Santos, s/n, bairro: Jardim das Américas, CEP: 81531-990. De segunda à sexta entre 13:00 até 18:00 horas,

Eu,_____ li o texto acima e compreendi a natureza e objetivo do estudo do qual meu filho foi convidado a participar. A explicação que recebi menciona os riscos e benefícios do estudo. Eu entendi que sou livre para interromper a participação no estudo a qualquer momento sem justificar minha decisão.

Eu concordo voluntariamente em meu filho participar deste estudo.

_____
(Assinatura responsável legal do sujeito de pesquisa)

_____
Evaldo José Ferreira Ribeiro Junior
CREF- 7557 – G/PR
Pesquisador Responsável

_____
Local e data

Aprovado pelo Comitê de Ética em Pesquisa em Seres Humanos do Setor de Ciências da Saúde/UFPR.
Parecer CEP/SD-PB nº 521630
na data de 05/02/2014

Comitê de Ética em Pesquisa do Setor de Ciências da Saúde da UFPR
Rua Padre Camargo, 280 2° andar, Alto da Glória, Curitiba, Paraná.
Telefone: (41) 3360-7259 e-mail: cometica.saude@ufpr.br

Anexo 5 – Termo de Assentimento da UFPR

MINISTÉRIO DA EDUCAÇÃO
UNIVERSIDADE FEDERAL DO PARANÁ
SETOR DE CIÊNCIAS BIOLÓGICAS
PÓS-GRADUAÇÃO EM BIOLOGIA CELULAR E MOLECULAR

UFPR Biológicas 75 anos

TERMO DE ASSENTIMENTO PARA TENISTAS INFANTO JUVENIS

Nome do Tenista:_____

- Meu nome é Evaldo Ribeiro Jr, faço doutorado na UFPR, estou realizando uma pesquisa que visa identificar medidas para caracterizar talentos esportivos.
- Você foi escolhido a participar do estudo pois foram selecionados todos os tenistas que participam de um treinamento continuo de tênis e torneios de tênis.
- Os conhecimentos buscados neste estudo podem te contribuir em melhores planejamentos, maior qualidade no controle da saúde a longo prazo do tenista em treinamento e melhor identificação de suas potencialidades.
- Você pode escolher em participar ou não, mesmo eu já tendo explicado ao seu pai do que se trata e ele concordado. Não há alguma obrigatoriedade em participar, você só aceita se achar que será útil e não te causar nenhum incomodo.
- Caso você participe da pesquisa, será feita uma avaliação física a cada 2 meses por 12 meses. A avaliação contém: Testes de corridas e saltos, questionários, fotocópia das duas mãos e coleta de saliva.
- A coleta consiste em bochechar água para limpar a boca, colocar um algodão de alta absorção de saliva na cavidade bucal e permanecer por um minuto até encharcar, após isto devolver ao tudo plástico do kit de coleta. O algodão deve ficar na boca movimentando-o para encharcar ao máximo, não tem gosto e esta lacrado, só sendo utilizado por você uma vez.
- Poderá causar ânsia momentânea, isto parará quando retirar o algodão da boca.
- Os testes de corrida e saltos não exigirão nada a mais do que já é feito nos treinos, mas pode haver risco de quedas acidentais.
- Mesmo aceitando participar e tendo iniciado, você pode retirar seu consentimento a qualquer momento.
- Os resultados individuais são anônimos pois sua saliva será identificada apenas por um código.
- Os resultados gerais serão divulgados após o final da pesquisa, e caso você queira saber o seu individualmente, cada avaliado terá acesso apenas ao seu próprio resultado.
- Esta pesquisa não tem fins lucrativos. Você não pagará e não receberá qualquer valor em dinheiro pela sua participação no estudo.

Eu, concordo em fazer parte de um estudo características de talentos esportivos em tenistas e para isso colocarei um algodão na boca, para encharcar de saliva e farei os testes físicos e questionários. Entendi que pode gerar algum desconforto e que sou livre para interromper minha participação no estudo a qualquer momento sem justificar minha decisão.

Eu concordo voluntariamente em participar deste estudo.

Assinatura da criança/adolescente:_____

Assinatura dos pais/responsáveis:_____

Ass. Pesquisador:_____

Dia/mês/ano:_____

Aprovado pelo Comitê de Ética em Pesquisa em Seres Humanos do Setor de Ciências da Saúde/UFPR.
Parecer CEP/SD-PB.nº 521.630
na data de 05/02/2014

Comitê de Ética em Pesquisa do Setor de Ciências da Saúde da UFPR
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