TATIANA GODOY BOBBIO

AVALIAÇÃO DA FUNÇÃO MOTORA EM ESCOLARES DE NÍVEIS SOCIOECONÔMICOS DISTINTOS E SUA RELAÇÃO COM O DESEMPENHO ESCOLAR

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Tese de Doutorado apresentada à Pós-Graduação da Faculdade de Ciências Médicas, da Universidade Estadual de Campinas, para obtenção do título de Doutora em Saúde da Criança e do Adolescente área de concentração em Saúde da Criança e do Adolescente.

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“A mente que se abre para uma nova idéia,

jamais volta ao seu tamanho original.”

Albert Einstein

RESUMO

Função motora se refere a fatores que envolvem a habilidade de usar e controlar os músculos estriados, responsáveis pela movimentação voluntária e é mais usada na área de coordenação motora. Função cognitiva entende-se por fases do processo de informação como percepção, aprendizagem, memória, atenção, vigilância, planejamento, raciocínio e solução de problemas. E o desempenho escolar, por fazer uso de todas as fases, pode ser definido como uma de suas ramificações do processo cognitivo. O desenvolvimento dessas duas funções era estudado separadamente, porém, atualmente, pesquisas têm demonstrado que estruturas cerebrais essenciais para a função motora, também são essenciais para as funções cognitivas e vice-versa. Os objetivos desse trabalho foram: (1) realizar revisão sistemática da literatura para investigar a relação entre estas funções, (2) avaliar a função motora e desempenho acadêmico de crianças de níveis socioeconômicos distintos e (3) observar a existência de associação entre a função motora e desempenho acadêmico. Foram avaliadas 402 crianças da primeira série do ensino Fundamental: 203 da escola pública e 199 de escola particular quanto à função motora por meio do Exame Neurológico Evolutivo ao inicio e ao final do ano letivo e quanto ao desempenho acadêmico por meio do Teste de Desempenho Escolar ao final do ano letivo. Um questionário contendo informações sobre os pais e a criança foi respondido previamente, pelo responsável. As escolas foram selecionadas intencionalmente para representar os dois níveis socioeconômicos distintos pretendidos. Na análise dos dados foram utilizados o teste qui-quadrado e razão de chances (*odds ratio*) pelo método de regressão logística multinomial. Para comparação entre as médias dos grupos utilizou-se o teste T de Student e Análise de Variância. Foi observada associação entre função motora e desempenho acadêmico, sendo que crianças com baixo escore na função motora apresentaram mais chance de baixo desempenho acadêmico. Sendo que crianças que passaram em menos provas de coordenação entre os membros apresentaram maior chance de baixo desempenho escolar comparadas as crianças que passaram em menos provas de controle motor fino seguido das provas de habilidades visuo-motora . Considerando o escore total na avaliação da função motora, as crianças da escola pública apresentaram uma escore médio significativamente mais baixo que as crianças da escola particular na tanto na avaliação inicial quanto na final. A coordenação entre os membros foi a categoria motora que mais contribuiu para a diferença entre as escolas. Ao comparar a primeira e a segunda avaliação em cada escola separadamente, pode-se verificar uma melhora na

função motora ao longo do ano letivo, porém o percentual de melhora foi maior na escola pública. Existe relação entre função motora e desempenho acadêmico, sendo que dificuldade motora pode contribuir para o fraco desempenho acadêmico. As crianças de nível socioeconômico menos favorecido têm desempenho mais baixo na função motora quando comparadas às crianças de nível socioeconômico mais favorecido.

Palavras-Chaves: Destreza motora, Escolar, Baixo rendimento escolar

ABSTRACT

Motor function refers to factors involving the ability to use and control the striated muscles that are responsible for voluntary movement, and is most used in the area of motor coordination. On the other hand, cognitive function refers to phases in processing information such as perception, learning, memory, attention, awareness, planning, reasoning and problem solving. Due academic performance use all these phases, so it can be defined as part of cognitive function. The development of these two functions has been studied separately; however, recent studies have shown that the brain structures that are essential for motor function are also essential for cognitive function and vice-versa. The objectives of this study were to perform a systematic review of the literature to investigate the relationship between these functions, to evaluate motor function and academic performance in children from different socioeconomic backgrounds and to verify the existence of a relationship between motor function and academic performance. A total of 402 first-graders, 203 in a public elementary school and 199 in a private school, were evaluated with respect to motor function using a Developmental Neurological Examination at the beginning and at the end of the academic year. The children's academic performance was evaluated using the School Performance Test at the end of the academic year. A questionnaire requesting information on the parents and child was previously filled out by the child's guardian. The schools were selected intentionally to represent the two different socioeconomic levels required by the protocol. Data were analyzed using the chi-square test of association and odds ratios according to the multinomial logistic regression method. Student's t-test and analysis of variance were used to compare means between groups. An association was found between motor function and academic performance, a lower score for motor function being associated with poorer academic performance. The risk of poor academic performance was greater when based on the interlimb coordination test rather than on any of the other categories investigated. The mean overall score obtained in the evaluation of motor function was 17.8 for the children in the public school and 19.7 for those in the private school at the first evaluation and 19.7 and 20.5, respectively, at the second evaluation, with a statistically significant difference between these means at both evaluations. Interlimb coordination was the motor category that most contributed to this difference between the schools. Comparing the first and second evaluation in each school separately, an improvement was found in motor function during the academic year; however, the percentage of improvement was greater in the

public school. There is an association between motor function and academic performance, poor motor function possibly contributing towards poor academic performance. Children from less favorable socioeconomic backgrounds have poorer motor function compared to children of higher socioeconomic levels.

Key-words: Motor skills, School, Underachievement

INTRODUÇÃO

1. INTRODUÇÃO

1.1 - Considerações Iniciais

Função motora se refere a fatores que envolvem a habilidade de usar e controlar os músculos estriados, responsáveis pela movimentação voluntária. É uma série de movimentos que combinados produzem uma ação eficiente e precisa (Gabbard, 2008). Tipicamente é mais usado na área de coordenação do que no contexto de velocidade e força motora (Piek et al, 2004).

A coordenação motora depende de um sistema funcional cujo embasamento é proporcionado pela sensibilidade profunda: o indivíduo é constantemente informado da posição exata de cada segmento de seu corpo e de suas mudanças (Umphred, 1994).

O cerebelo é considerado o centro da coordenação motora. Ele recebe informações do córtex cerebral para cada comando motor, e informações dos músculos em relação ao movimento a ser efetuado. Da comparação de informações de origens central e periférica, resulta um sinal que é enviado ao córtex motor que pode modificar sua mensagem aos músculos com o objetivo de tornar o movimento adequado e harmônico (Sanvito, 2000).

Por função cognitiva entende-se fases do processo de informação como percepção, aprendizagem, memória, atenção, vigilância, planejamento, raciocínio e solução de problemas (Flavell et al. 1999; Antunes et al, 2006). Diferente da função motora, a função cognitiva não possui uma localização específica no SNC (Sistema Nervoso Central), uma vez que é composta por diversos orgãos sensoriais, entre eles a visão e a audição, requerendo assim, a ação integrada de neurônios em diferentes regiões. Processos mentais como pensar e aprender, por exemplo, são compostos de diversos componentes independentes e processadores de informações, e até mesmo a mais simples tarefa cognitiva demanda a coordenação de diversas áreas cerebrais distintas (Diament e Cypel, 2008).

Teorias tradicionais admitiam que o desenvolvimento motor infantil obedece uma seqüência hierárquica e invariável, na dependência da maturação do córtex e alheio às influências externas (Bobath, 1994). A maturação parece se traduzir por uma sequência de comportamentos cronologicamente ligados à idade, mas trata-se, sem dúvida, de um processo dinâmico complicado onde os movimentos precoces se modificam para ceder lugar às funções habilidosas e maduras (Silva e Souza, 1997).

Estudos recentes apontam que o aumento na maturação do córtex promove melhora nas funções motoras, porém o desenvolvimento está intimamente ligado às estimulações que a criança recebe do ambiente em que está inserida (Shevel et al., 2005). Para Folio e Fellew (2000) o comportamento motor emerge como consequência da interação entre maturação e experiência da criança.

A habilidade motora parece ser grandemente influenciada por fatores externos como: condições nutricionais, fatores socioeconômicos e culturais, relação com os pais e participação destes na rotina da criança e nível de quociente de inteligência da mãe (Rocha e Tudella, 2002; Capellini et al. 2008). Da mesma forma, os aspectos cognitivos interagem de maneira organizada e seu desenvolvimento muda de acordo com o ambiente e fatores pessoais da criança que moldam e determinam o ritmo e direção do desenvolvimento cognitivo.

1.2 Relação entre as funções motora e cognitiva

Embora a idéia de uma possível relação entre o desenvolvimento motor e cognitivo ter tido início com Piaget em 1953, que afirmou que processos cognitivos e motores parecem não ser entidades separadas e que o desenvolvimento cognitivo parece depender da função motora (Piaget e Inhelder, 1966), o desenvolvimento dessas duas funções até poucos anos atrás era estudado separadamente (Wassemberg, 2005).

O desenvolvimento cognitivo era visto como o último aspecto do desenvolvimento global infantil para o alcance da maturação completa. Porém, os pesquisadores se esqueciam que o desenvolvimento motor era igualmente demorado. Controle motor fino, coordenação bimanual e habilidades visuo-motoras, por exemplo, não estão completamente desenvolvidas até a adolescência, mesmo período em que as funções cognitivas mais complexas começam a se aprimorar (Diamond, 2000).

Já existiam evidências nos últimos 55 anos que o desenvolvimento filogenético do neocerebelo (região mais nova do cerebelo) e o do cortex pré-frontal aconteciam paralelamente. Mesmo assim, o cortex pré-frontal era tido como essencial apenas nas habilidades cognitivas, enquanto que o neocerebelo era considerado essencial para as habilidades motoras, não sendo vistos participando de funções semelhantes (Diamond, 2000)

Evidências atuais nos achados de exames de neuroimagem contribuíram para uma mudança nesta visão, mostrando que áreas que antes acreditava serem essencialmente destinadas à função motora no SNC, também têm sido consideradas essenciais para as habilidades cognitivas e vice-versa (Diamond, 2000; Piek et al., 2004).

Os achados revelaram que diante de uma tarefa cognitiva, por exemplo, é possível observar um aumento na ativação no cortex pré-frontal dorsolateral e simultaneamente um aumento da ativação no neocerebelo. Além disso, ambas as áreas parecem seguir um tempo de desenvolvimento semelhante com acelerada progressão entre 5 e 10 anos de idade (Wassenberg et al., 2005).

Diversas pesquisas têm contribuído para demonstrar essa relação entre as funções (Rintala et al., 1998; Webster et al., 2005; Roebers e Kauer, 2009). Bushenell e

Bordreau (1993) sugerem que o desenvolvimento motor serve como “parâmetro de controle” para o desenvolvimento futuro e que habilidades motoras são pré-requisitos para a aquisição e prática de outras funções como habilidade perceptual ou cognitiva. Afirmam ainda que, o desenvolvimento motor, provavelmente, determina a sequência nas quais certas habilidades cognitivas se desenvolvem. A marcha idiopática nas pontas dos dedos, por exemplo, uma anormalidade motora de causa desconhecida, é considerada precursora de problemas de aprendizado e desenvolvimento da fala (Sala et al.,1999; Shulman et al., 1997).

Wijnroks e van Veldhoven (2003) observaram que crianças com pobre controle postural de tronco aos 6 meses tinham mais dificuldades nas tarefas cognitivas comparadas às crianças com bom controle postural. Burns et al. (2004) avaliaram crianças com e sem atraso motor aos 12 meses e 4 anos de idade e observaram que a dificuldade cognitiva estava associada ao grupo com dificuldade motora tanto aos 12 meses quanto aos 4 anos .

Estudos realizados com crianças com Transtornos de Déficit de Atenção e Hiperatividade (TDAH) têm demonstrado que além da dificuldade cognitiva essas crianças apresentam também problemas na função motora (Kaplan et al.,1998; Piek et al., 1999). Da mesma forma, estudos realizados nas crianças com Transtorno do Desenvolvimento da Coordenação (TDC) também evidenciaram dificuldades cognitivas associadas às dificuldades motoras já conhecidas (Dewey et al., 2002; Alloway, 2007; Alloway e Temple, 2007).

Por envolver as mais diversas fases do processo de informação, o desempenho acadêmico escolhido para mensurar a função cognitiva no trabalho atual.

1.3 Interferência da função motora no desempenho escolar

Os efeitos dos atrasos motores no desenvolvimento infantil têm sido amplamente investigados e sua interferência na função cognitiva tem ganhado atenção considerável. Na criança em idade escolar, dificuldades na função motora, principalmente na coordenação, parecem prejudicar as funções cognitivas que, por sua vez, dificultam o bom desempenho da criança na escola. Para Dewey e Wilson (2001) as dificuldades motoras na idade escolar estão sempre associadas à dificuldade acadêmica.

Os estudos de Muray et al. (2007), realizados em uma amostra da população finlandesa, indicou que quanto mais rápido ocorre o desenvolvimento motor melhor a performance da criança em alguns domínios cognitivos indispensáveis para o desempenho escolar e, consequentemente, para a realização educacional.

Wassemberg et al. (2005) observaram que a performance motora no jardim da infância tem mostrado estar relacionada às conquistas de leitura e linguagem na primeira série escolar. Dificuldades nessas áreas são onde frequentemente se manifesta o atraso motor. (Oliver, 1990; Wassenberg et al., 2005). Riou et al. (2009) ao estudarem se crianças com atraso motor global instalado também apresentavam atraso cognitivo, observaram que o desempenho motor fino foi preditor de valor de Quociente de Inteligência global, o que provavelmente mostra a importância da sobreposição entre a coordenação motora e cognição na criança escolar.

A coordenação motora é um determinante no progresso educativo das crianças, assim como no desenvolvimento integral (Lopes et al., 2003). Dificuldades na a escrita e nas demais tarefas que demandem coordenação talvez tragam futuras desvantagens à criança (Losse et al., 1991).

A presença de dificuldade motora afeta a participação da criança na escola, quer em atividades recreacionais ou em sala de aula. Falhas precoces na escola podem ter um impacto negativo importante no bem-estar da criança e isso pode diminuir sua auto-estima e motivação (Cross e Fowler, 1986).

A dificuldade escolar é queixa frequente nos ambulatórios e consultórios de pediatria, e o motivo de encaminhamento ao neuropediatra. Além disso, também é apontada como colaboradora de dois grandes problemas no nosso Sistema Educacional: os altos índices de repetência e evasão escolar entre os alunos brasileiros.

De acordo com o Censo Escolar do MEC de 2008, a taxa de abandono escolar é de 3,2% de primeira a 4ª. série subindo para 6,7% de 5ª. a 8ª. série. Embora pareça pequeno, corresponde a quase um milhão e meio de alunos. Não menos preocupante, o índice nacional de repetência varia de 15 a 50%, sendo mais elevado nas primeiras séries do ensino fundamental. Os alunos levam em média doze anos para concluir as oito séries do ensino fundamental (Censo INEP, 2009).

Déficits no desenvolvimento motor têm parecido preceder relato de fraco desempenho acadêmico. A possível existência de relação entre ambas as funções auxiliaria terapeutas, educadores e familiares na escolha de uma intervenção adequada focando tanto na função motora quanto cognitiva, potencializando seus benefícios.

1.4 Avaliação das habilidades

As várias etapas e áreas do desenvolvimento neuropsicomotor da criança refletem o desenvolvimento de seu SNC, sendo, portanto, importantes marcadores neurológicos de sua integridade (Umphred, 1994). O SNC da criança é um sistema em constante evolução e transformação. Desde a vida intra-uterina, ele se desenvolve e amadurece, e esse desenvolvimento se processa até a idade adulta por meio de processos de maturação e transformação. Essas modificações são resultantes da interação entre forças intrínsecas, de ordem genética e extrínsecas, que dependem do ambiente em que a criança vive. O resultado final da interação entre estes fatores é que determina o desenvolvimento neuropsicomotor da criança (Rugolo, 1997).

O uso de avaliações padronizadas é essencial para os profissionais na identificação de crianças com problemas no desenvolvimento (Stokes et al., 1990). Segundo Van Kolck (1981) o termo padronização diz respeito à uniformidade do processo na aplicação, avaliação e interpretação do teste.

As avaliações servem para determinar se a criança está tendo um desenvolvimento típico ou se está com algum atraso, ou ainda, necessitando de algum atendimento especial (Crowe et al., 1999). Embora as normas de referência das avaliações do desenvolvimento motor freqüentemente sejam usadas como medidas para auxiliar a efetividade do tratamento utilizado (Palisano et al., 1995).

Os modelos de avaliações usados no adulto não se aplicam a lactentes e crianças. Nesta população os diagnósticos dos prejuízos no SN são rotineiramente realizados com base nos desvios do padrão normal das aquisições marcantes. Estes desvios podem ser quantitativos ou qualitativos, o que é um ponto importante, porque muitas avaliações do desenvolvimento confiam somente na informação quantitativa e desprezam "como" a criança alcançou o resultado. A maneira como é adquirida e a qualidade destas aquisições marcantes são tão, ou mais importantes do que se o teste foi ou não realizado (Aylward, 1997). Segundo Tieman et al. (2005) a seleção de um instrumento de medida adequado dependerá do propósito do teste e características da criança, e devem conter aspectos como:

- Validade ou vigência: o teste deve medir aquilo que se propõe medir;
- Confiabilidade ou fidedignidade: os dados do teste devem ser capazes de serem reproduzidos e obtidos igualmente por diferentes avaliadores;

- Especificidade e sensibilidade: requer que o lactente ou criança normal seja identificada como tal.

Dentre as escalas motoras que avaliam o pré-escolar e o escolar, destaca-se o Exame Neurológico Evolutivo (ENE) desenvolvido por Antonio B. Lefévre (1972) e padronizado em crianças brasileiras. Seu plano de trabalho consistiu em programar um conjunto de 124 provas para avaliar os principais itens que traduzem o funcionamento evolutivo do SN de crianças de 3 a 7 anos, obedecendo ao critério de tornar mais sensíveis algumas provas que fazem parte do exame neurológico tradicional.

As 124 provas foram divididas em blocos que compuseram os exames da fala, do equilíbrio estático, do equilíbrio dinâmico, da coordenação apendicular, da coordenação tronco-membro, das sincinesias, da persistência motora, do tono muscular e da sensibilidade. Em cada exame as provas foram distribuídas desde as de mais fácil execução às mais difíceis, sendo divididas em grupo por idade, subentendendo-se que a criança aos sete anos era capaz de realizar todas as provas selecionadas. A avaliação é realizada individualmente, com a criança vestida e sem sapatos, recebendo os escores de: "passou" quando conseguiu realizar o que foi solicitado ou "falhou", quando não foi capaz de realizar a solicitação (Lefévre, 1972).

O exame de coordenação apendicular consta de 28 provas que informam sobre direção e medida do movimento, desenvolvimento da capacidade práxica, disposição de sinergias nos movimentos e demais, que permitem investigar um tipo de coordenação muito importante para o aprendizado escolar. Sabe-se que a organização perceptiva e motora, do espaço é necessária para a escrita, pois há uma evolução gráfica que muda com a idade (Lefévre, 1972).

Para Bessa e Ferreira (2002) é fundamental a avaliação da coordenação motora na idade pré-escolar da criança, pois a alteração de tais habilidades pode interferir na aprendizagem escolar e na conduta geral.

Dentre as avaliações do desempenho escolar, o Teste de Desempenho Escolar (TDE) desenvolvido por Stein (1994) é um instrumento psicométrico que busca oferecer de forma objetiva uma avaliação das capacidades fundamentais para o desempenho escolar e está fundamentado em critérios elaborados a partir da realidade escolar brasileira.

O teste foi concebido para a avaliação de escolares de primeira a 6ª. série do ensino Fundamental. É composto por três categorias (Escrita, Aritmética e Leitura) com 143 provas no total, realizadas individualmente. Cada categoria apresenta uma escala de itens em ordem crescente de dificuldade. Ao final os escores de cada categoria e o escore total de todo o TDE são convertidos por intermédio de uma tabela de classificação de acordo com a idade.

Para Lima (2008), a utilização de um instrumento para a avaliação do desempenho escolar é fundamental para promover a aprendizagem da criança e traçar uma trajetória de sucesso, uma vez que sua finalidade é identificar e analisar as dificuldades encontradas dentro do processo educacional.

OBJETIVOS

2. OBJETIVOS

2.1 Objetivo Geral

Avaliar a função motora – coordenação motora grossa, coordenação motora fina e coordenação visuo-motora – em escolares da primeira série do ensino Fundamental de dois níveis socioeconômicos distintos ao início e ao final do ano letivo e observar sua relação com o desempenho acadêmico.

2.2 Objetivos Específicos

Capítulo 1: "The Relationship Between Motor Function and Cognitive Performance: a Sistematic Review"

O objetivo do estudo foi realizar uma revisão sistemática da literatura para observar a relação entre função motora e cognitiva de maneira global em crianças consideradas como tendo desenvolvimento típico.

Capítulo 2: "Interlimb Coordination Differentiates Brazilian Children From Two Socioeconomic Settings"

Os objetivos deste estudo foram: a) avaliar a função motora de escolares de níveis socioeconômicos distintos ao início e final do ano letivo e b) qual tipo de função motora mais diferencia os dois grupos.

Capítulo 3: “The Relationship Between Motor Function and Cognitive Performance”

Os objetivos deste estudo foram: a) observar se a função motora esta associada ao desempenho acadêmico e b) observar qual tipo de função motora mais contribui para estarelação.

MATERIAS E MÉTODOS

3. MATERIAS E MÉTODOS

O estudo foi aprovado pelo comitê de Ética em Pesquisa da Faculdade de Ciências Médicas da Universidade Estadual de Campinas parecer no. 594/2006.

3.1. Tipo de Estudo

O estudo realizado foi do tipo descritivo e observacional, realizado sem intervenção.

3.2. Desenho do Estudo

Para representar adequadamente os dois níveis socieconômicos distintos pretendidos, foram selecionadas uma escola da rede pública escolhida por atender as crianças moradoras de uma favela próxima e duas escolas da rede particular, escolhidas por terem uma mensalidade acima de três salários mínimos.

3.3. Seleção dos sujeitos

Foram selecionados todos os escolares da 1ª. série do ensino Fundamental das escolas selecionadas.

3.4. Critérios de Inclusão

Foram incluídos no estudo escolares cursando pela primeira vez a 1ª. série do ensino Fundamental, com freqüência escolar regular e escolares sem necessidades especiais.

3.5. Critérios de Exclusão

Foram excluídos no estudo escolares que não desejaram ser avaliados, mesmo que seus pais houvessem consentido com a pesquisa, que realizaram apenas uma avaliação da função motora, com comprometimentos neurológicos, que estavam sob uso de medicação das funções estudadas e crianças com distúrbios auditivos, visuais e mentais.

3.6. Tamanho da amostra

O tamanho da amostra foi calculado após a realização de um projeto piloto com 10 crianças de cada escola. Para garantir um poder de teste de 80% (α= 0,05 e β 20%) com hipótese bicaudal, seriam necessárias no mínimo 163 crianças de cada escola.

3.7. Critérios para evitar viés

Para evitar viés de treinamento pelos estímulos do ambiente escolar, a primeira avaliação da função motora foi realizada no primeiro mês de ingresso no ensino fundamental.

3.8. Instrumentos de Avaliação

3.8.1. Avaliação Motora

A função motora foi avaliada por meio do Exame Neurológico Evolutivo (Lefevré, 1971) que é composto por uma bateria de 11 testes, entre eles o da Coordenação Apendicular utilizado no estudo.

O instrumento foi escolhido por avaliar crianças na idade pretendida, ser de fácil aplicação e ter sido padronizada em crianças brasileiras.

A bateria da Coordenação Apendicular é composta de 28 provas que informam: direção e medida do movimento, desenvolvimento da capacidade práxica, disposição de sinergias no movimento e orientação espacial.

Devido às provas da coordenação apendicular não utilizarem apenas os membros superior para a realização das tarefas, e devido ao termo não ter uma tradução adequada para o idioma Inglês foi sugerido uma reclassificação quanto ao tipo de função motora que as tarefas avaliavam. Para reclassificação contou-se com a ajuda de quatro conceituados pesquisadores do desenvolvimento infantil de diferentes universidades dos Estados Unidos.

As provas foram reclassificadas como nove provas que avaliavam a habilidade visuo-motora, quatro que avaliavam o controle motor fino e oito que avaliavam a coordenação motora grossa.

As crianças receberam o escore de F (falha) quando não conseguiam atingir o objetivo da prova e P (passa) quando conseguiam atingir o objetivo. Ao final eram classificadas como tendo função motora Adequada para idade, ao realizarem duas ou mais provas da bateria dos sete anos ou Inadequada para a idade, quando realizavam uma ou nenhuma prova da idade.

Foram realizadas duas avaliações, uma no início e uma no final do ano letivo. Para a aplicação do exame uma instrução prévia era dada pelo avaliador e a criança tinha 2 tentativas para a realização da prova.

3.8.2 Avaliação do Desempenho Acadêmico

A avaliação do desempenho acadêmico foi realizada por meio do Exame do Desempenho Escolar (Stein, 1994) que avalia crianças de 1ª. a 6ª. série do ensino Fundamental.

Foi escolhido por poder ser aplicado por qualquer profissional e ter sido padronizado em crianças brasileiras. O instrumento é composto por três categorias: Escrita, Aritmética e Leitura.

A criança recebia 1 ponto para cada prova correta e ao total um Escore Bruto da somatória das provas realizadas (total de 143 pontos).

Apenas uma avaliação no final do ano letivo foi aplicada.

CAPÍTULO 1

RELATIONSHIP BETWEEN MOTOR AND COGNITIVE FUNCTION: A SYSTEMATIC REVIEW

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Abstract

Objective: To perform a systematic review by selecting and analyzing studies published between January 1980 and October 2009 that investigated the relationship between motor and cognitive function. ***Methods:*** A search was performed of the principal electronic databases: Cochrane Library, PubMed, SciELO, National Library of Medicine (Medline), Latin American and Caribbean System on Health Sciences Information (LILACS) and Physiotherapy Evidence Database (PeDro), with no restrictions regarding language of publication. Studies were selected in which the relationship between motor and cognitive function in general was evaluated in children up to 15 years of age with normal development. Reviews and case studies were excluded. ***Results:*** In the five studies selected, a relationship was shown between motor and cognitive function. Low motor function scores appear to be indicative of low cognitive function scores. Associations were also found between certain aspects of the two functions. ***Discussion:*** Although an association has been found between motor and cognitive function, further studies need to be undertaken in normal children to provide a comprehensive evaluation of motor and cognitive function in order to obtain more accurate data on this association. In addition, in view of the effect of the experiences to which a child is exposed during his/her development, longitudinal studies are recommended.

Key-words: psychomotor performance, motor skills, child behavior, motor activity, cognitive aspects, task performance

Relationship between motor and cognitive function: a systematic review

The term *motor function* refers to factors that involve the ability to use and control the striated muscles responsible for voluntary movement. The function consists of a series of movements that, in conjunction, result in an effective and precise action [1]. Typically, it is more often used in relation to coordination than in the context of speed and motor strength [2]. On the other hand, cognitive function is understood to refer to the phases involved in processing information such as perception, learning, memory, attention, awareness, reasoning and problem solving [3].

Up to 20 years ago, the development of these two functions was discussed as separate entities, despite the fact that they occur within the same organism and within a similar time span. Today, however, there is an increasing consensus that motor and cognitive function are fundamentally related [4].

The debate on the relationship between aspects of motor and cognitive performance in general first began with Descartes (1596-1650), who affirmed that cognitive processes are entirely different from motor processes [5]. Later, Piaget stated that cognitive and motor processes do not appear to represent separate entities and that cognitive development seems to depend on motor function [6]. Churchland [7,8] formulated a more subtle association between cognitive and motor function, affirming that if we wish to understand cognition, we must first comprehend its emergence in evolution; therefore its origin in sensory-motor control must be understood.

Bushnell and Bordeau [9] agreed that an overall relationship exists between cognitive and motor function, affirming that motor control determines the sequence in which certain perceptual and cognitive abilities occur. This notion is experimentally supported by the finding that the development of spatial ability in children is facilitated by locomotor experience [10-12].

Neurobiological data on the specific relationship between cognitive and motor development originate from recent studies showing that the development of both functions extends up to adolescence. Neuroimaging exams have shown that areas in the central nervous system (CNS) essentially responsible for motor function have also been considered essential for cognitive abilities and vice-versa [4,13].

Various studies have suggested the existence of a relationship between motor and cognitive function; however, few experimental studies have been performed to investigate this relationship in a comprehensive manner [14,15]. Many studies are restricted to reporting one single aspect of each function such as the relationship between fine motor coordination and learning. Alternately, studies are designed to look for the effect of one of these functions in children in whom a deficiency has already been identified in the other function, such as studies that focus on attention deficit hyperactivity disorder (ADHD) and investigate problems that may also exist in motor performance [16]. Just as expressive is the number of studies in which the association between motor and cognitive function has been evaluated in preterm infants who, according to the literature, are predisposed to delays both in cognitive and motor function.

According to Shevel et al. [17], motor development deficits appear to precede reports of poor academic performance. Establishment of the existence of a relationship between cognitive and motor function would help therapists, educators and families select an adequate intervention, focussing both on motor and cognitive function in order to maximize benefits.

Therefore, the objective of the present study was to perform a systematic literature review on the relationship between motor and cognitive function in general in children with "normal" development.

Methods

A systematic search of the literature was conducted between February and October, 2009 in the principal electronic databases: Cochrane Library, PubMed, SciELO, National Library of Medicine (Medline), Latin American and Caribbean System on Health Sciences Information (LILACS) and Physiotherapy Evidence Database (PeDro). No restriction was made with respect to the language of publication.

The key words used to search the databases were: "*motor function*" or "*motor development*" or "*motor performance*" or "*motor assessment*" or "*motor control*" together with "*cognitive function*" or "*cognitive development*" or "*cognitive performance*" or "*cognitive control*" or "*school performance*", and their equivalent in various other languages. The search was limited to articles published between January 1980 and October 2009.

The inclusion criteria adopted for the selection of papers were: a) quantitative studies; b) studies involving a comprehensive investigation of the association between motor and cognitive function; c) studies designed to collect data and analyze findings and d) studies that evaluated populations up to 15 years of age.

The exclusion criteria applied were: a) studies that evaluated populations with neurological disorders affecting motor function and/or other pathologies; b) populations with known cognitive deficiencies; c) populations in use of medication for the control of motor and/or cognitive activity; d) studies that evaluated the efficacy of motor and/or cognitive therapy; e) articles involving preterm infants; and f) studies that established a direct association between motor and cognitive function mediated by a secondary factor such as, for example, attention. In addition, case studies, chapters of books, theses and masters dissertations that had not been published in the form of an article were excluded.

The process for selecting the articles used in the study was performed by one of the authors and a librarian experienced in carrying out systematic reviews. The following steps were taken: 1) studies were identified by cross-referencing key words; 2) papers were preselected based on their titles; 3) an initial selection was made by reading the abstracts; 4) an intermediate selection was made based on some predetermined inclusion and exclusion criteria; and 5) the final selection was made after reading the entire paper and verifying the adequacy of the inclusion and exclusion criteria.

A total of 563 papers were initially identified by cross-referencing the key words; however, only 85 were found to be in agreement with the precise key words established in the study protocol. After reading the titles, 53 papers were preselected and 21 were found to satisfy some of the preestablished criteria. After reading these papers in their entirety, 16 articles were excluded because they did not deal comprehensively with cognitive and motor function or because they dealt with a sample population consisting of preterm infants. Finally, five papers were selected as adequately fulfilling all the inclusion and exclusion criteria (Figure 1).

One of the papers selected compares the relationship between motor and cognitive function in children with a birthweight of < 1250 grams and in children of normal birthweight. Since this study was deemed to be important, this paper was included; however, only the results of the group of children with normal birthweight were considered in the analysis.

The studies selected were evaluated maintaining the terminology used by the author, the year of publication, the place and country in which the study was performed, the type of study, the sample size and the origin of the sample population (Table 1). The quality of the methodology used in the selected studies was evaluated using criteria on the type and design of the study, description of the study population, description of the instrument used, statistics, relevance and originality, as described in the Cochrane Handbook [18].

Results

Classification of the articles

Five experimental studies were included in this review, making a total of 1,631 participants who met the inclusion criteria established for this systematic review.

With respect to methodology, two articles were considered to be of good quality, while the methodological quality of the remaining three was considered average or weak. The following factors contributed directly to the final classification of the papers: methodological design of the study; control for confounding factors such as age, gender, prematurity, socioeconomic level, family history and previous therapeutic procedures; consent of the parents for the child to participate; use of standardized evaluation instruments; information on the instrument used; and data analysis (Table 2).

Evaluation instruments

None of the studies used single scales for evaluating both functions, i.e. no single instrument contained a battery of questions capable of evaluating motor function and another battery that dealt with cognitive function. In four studies the instruments used to evaluate motor function had been developed and standardized in the country in which the study took place. In one study, the investigators used tests from different instruments to compile their own motor evaluation instrument, while in two other studies, this same procedure was used to compile an instrument to evaluate cognitive function. Only two studies reported on the reliability and validity of the instrument used to evaluate motor function.

Among the aspects of motor function evaluated, four studies assessed fine motor skills, gross motor skills and balance. One study stated that motor performance was evaluated quantitatively and qualitatively.

The age-group covered by the cognitive tests was clearly defined in only one of the studies, while three provided this information for the motor tests. Tables 3 present data on the motor and cognitive instruments used.

Relationship between motor and cognitive function

All the studies reported a correlation between cognitive and motor function. Roebers and Kauers [14] and Seitz et al. [15] reported this correlation as weak, albeit reliable.

According to Roebers and Kauers [14], Seitz et al. [15] and Wassemberg et al. [19], the substantial number of correlations found between these functions indicates that aspects of executive function are shared by domains of motor and cognitive function.

Bobbio et al. [20] evaluated schoolchildren at the beginning and at the end of the school year and found that children with low motor function scores also scored poorly with respect to cognitive ability in both evaluations (χ^2=102.0; p<0.01 and χ^2=85.4; p<0.01, respectively). A greater likelihood of a low cognitive score was found for children with poor motor performance. At both evaluations, there was an association between cognitive function and fine motor skills (χ^2=121.2; p<0.01 and χ^2=62.9; p<0.01) and between cognitive function and gross motor skills (χ^2=76.3; p<0.01 and χ^2=68.3; p<0.01).

Roebers and Kauers [14] controlled their analyses for age. These authors reported a correlation between all cognitive function tests and all motor function tests, the range of the correlation coefficient (r) being between 0.22 and 0.50. A correlation was found between memory and static balance (r=0.34), between memory and speed of response and gross motor skills (r=0.29), between memory and speed of memory and dynamic balance (r=0.20), and between decision-making and execution and gross motor skills (r=0.31) and balance (0.21).

Seitz et al. [15] reported a significant correlation between cognitive process and fine motor skills (r=0.41), gross motor skills (r=0.37) and static balance (r=0.36). In cognitive function subtests, a strong correlation was found between fine motor skills and simultaneous cognitive processes (r=0.40), gross motor skills and sequential cognitive processes (r=0.30), gross motor skills and simultaneous cognitive processes (r=0.40) and static balance with simultaneous cognitive processes (spatial memory) (r=0.38). Spacial memory was found to be correlated with all aspects of motor function. These investigators found that the risk of poor cognitive function associated with motor difficulty was 60% in fine motor skills [OR: 6.0; 95%CI: 4.7-7.3], 70% in gross motor skills [OR: 7.0; 95%CI: 5.6-8.4] and 90% in static balance [OR: 9.6; 95%CI: 8.2-11.0].

Wassember et al. [19] evaluated motor function in general, qualitatively and quantitatively, and found a correlation between cognitive function and all aspects of motor function. Nevertheless, these investigators found that when controlled for attention, the relationship with quantitative motor performance disappeared. In regression analysis, they reported that all aspects of motor function were associated with visuomotor function (r=0.05) and with memory (r=0.04). In addition, verbal fluency was associated with quantitative motor function (r=0.04). In logistic regression, deficient motor performance was found to exert an effect on three aspects of cognition: visuomotor function [OR: 4.9; 95%CI: 1.18-20.6], verbal fluency [OR: 3.3; 95%CI: 1.23-7.4] and memory [OR: 2.9; 95%CI: 1.3-6.4].

Planinsec [21] separated data according to gender; however, in both boys and girls an association was found between motor and cognitive domains, although the correlation coefficient was not very high (boys: r=0.26; girls: r=0.21). In general, the motor skill domains most associated with the cognitive domains were those involving coordination and speed of movement. In girls, a greater association was found between cognitive function and explosive strength, while in boys the correlation was greater between cognitive function and balance.

Discussion

The studies included in this review [14,15,19-21] showed a clear association between motor and cognitive function. This association was found to be directly proportional.

In general, these data support the hypothesis of a close association between motor and cognitive development and confirm that both functions develop concomitantly [13]. There is evidence that aspects of cognitive performance related to abstraction, behavior planning and executive function develop at 5 to 10 years of age [21-23] and at this same age rapid development of some motor processes such as movement control and motor skills also occurs [24].

The prefrontal cortex appears to be crucial for the more complex cognitive skills, whereas the cerebellum manages motor skills. Recent studies using functional brain imaging techniques show that the cerebellum is also activated both during new cognitive operations and during complex operations [13,25,26]. Other structures such as the basal ganglia and the frontal cortex, as well as certain neurotransmitters such as dopamine, are also believed to be involved in aspects of higher order motor and cognitive performance [13,27,28].

Neuroimaging studies have shown that when a cognitive task increases activation of the dorsolateral prefrontal cortex, an increase is also found in the activation of the neocerebellum. This coactivation of the prefrontal cortex and neocerebellum has been found in tasks involving verbal fluency and those that involve learning and memory [13]. Muria et al. [29] found that lesions in the prefrontal cortex may result in hypometabolism in the contralateral cerebellum.

Studies focusing on development disorders such as attention deficit hyperactivity disorder (ADHD) have suggested an association between motor and cognitive performance. These disorders occur in association with both cognitive and motor deficits [30-32].

Likewise, neurological data support the finding that children with Developmental Coordination Disorder do not only have severe problems with motor skills, but also in the execution and control of cognitive tasks [33,34]. These children have been found to suffer memory deficits, to have problems performing school work and to score lower in intelligence tests compared to motor control tests [33, 36-38].

According to Foulder-Hughes and Cooke [39], motor delays are associated with the intellectual process in visual and verbal domains. Robinson [40] found that 90% of the children in a sample population with language difficulties also showed evidence of motor delays. Rintala et al. [41] evaluated 76 children with communication difficulties and found that 71 had concomitant motor difficulties. The association between memory and verbal fluency and motor performance suggests that certain brain structures such as the basal ganglia and the frontal cortex are common to cognitive and motor function.

The effect of delays or disorders in early motor development has already been studied. For example, walking on tip-toe, a motor abnormality with no known cause, is considered a precursor to developing language and learning problems [42,43]. Motor function problems early in life are a precursor to problems in acquiring language and attention skills [44-46].

In addition to an overall association between motor function and cognitive function, the studies included in this review indicated a relationship between some features of motor function and certain aspects of cognitive function such as, for example, balance and memory. For Shevel et al. [17], difficulties in overall development may be operationally defined as a significant disorder in two or more domains (fine/gross motor skills, visuomotor coordination, memory, language or personal/social).

Brêtas et al. [47] evaluated 86 children of 6-10 years of age and reported that with respect to motor function, the children had major difficulty with fine motor skills while with respect to cognitive function difficulties were found in relation to memory and visuomotor skills. For Wassemberg et al. [19], this association is to be expected since visuomotor function involves many of the features related to fine motor skills. In kindergarten children with poor academic performance, Bart [48] reported an association with visuomotor difficulties and attributed this to the fact that 30-60% of school activities involve fine motor skills.

Volman et al. [49] studied children with writing difficulties and reported abnormalities in the memory and balance of these children. Some studies [50,51] found that at least half the children with memory difficulties have poor gross motor skills. Deficits in executing coordinated movements are evident in children with dyslexia and specific language disorders [52].

Of the studies selected for this review, only one was performed longitudinally. Although the evaluation instruments were designed to classify motor and/or cognitive performance at the actual time of assessment, evaluations performed over time would enable investigators to observe whether the association between functions persists and would provide further information for individuals working with these children. Longitudinal evaluations are recommended in order to improve the validity of instruments, since not every evaluation method is capable of establishing whether or not every child has difficulties in certain functions with one single evaluation [53]. Moreover, child development may be the subject of constant intrinsic effects such as maturation of the central nervous system and extrinsic effects that include environmental, social and cultural factors [54]. Therefore, the association between motor and cognitive function may change over the years.

In view of the indications that motor function and cognitive function are interconnected, various studies have attempted to identify difficulty in one function when difficulty in the other has already been preestablished [52]. Nonetheless, few studies have analyzed this association in children without difficulties, a situation that is reflected in the fact that only five articles were selected for inclusion in this systematic review.

This investigation is important because some of the situations that result in difficulties in academic performance may be related to difficulties in motor function, since this directly affects cognitive function in children. According to Rosemblum and Livneh-Zirinski [55], motor difficulties, such as problems with coordination, may lead to difficulties in essential activities mandatory for the success and participation of the child at school, representing a vital component in the child's self-esteem.

For Brêtas et al. [47], investigation of the child's development and related problems permits not only timely intervention and implementation of programs to stimulate the child, but principally allows a stimulating environment to be created.

Observation of the association between motor and cognitive function suggests that, when an abnormality is detected in one of these functions, the other should also be evaluated. It is also recommended that intervention processes should focus both on motor function and on cognitive function in order to maximize benefits.

Although an association has been found between these functions, further studies need to be conducted in populations of normal children to evaluate motor and cognitive function in a more comprehensive manner with the objective of providing more accurate data on this relationship. In addition, due to the effects of the experiences to which children are exposed during their development, longitudinal studies are recommended.

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Figure 1: Selection methods

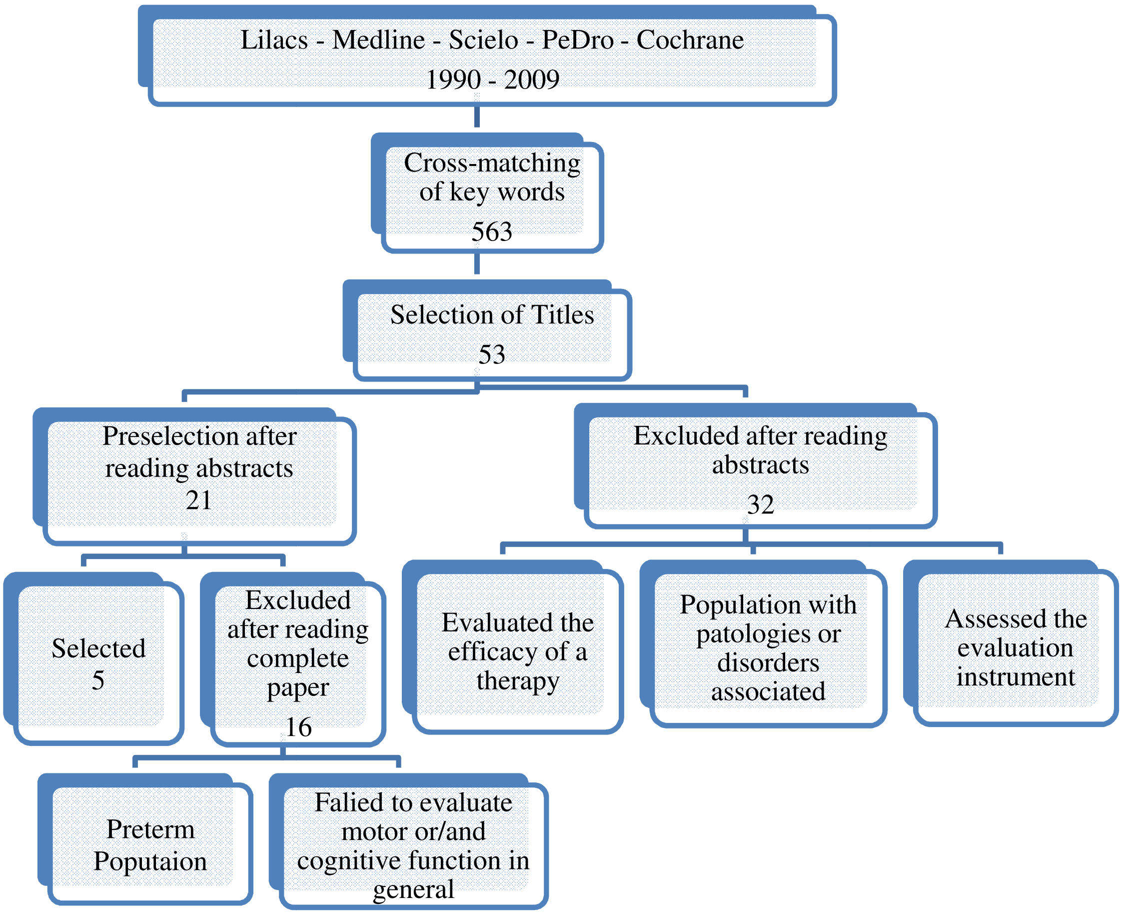

Table 1. Relationship between motor and cognitive function studies (N=4)

Author and Year of publication	**University**	**Country**	**Type of study**	**Sample Size**	**Where sample comes from**
Bobbio et al. (2009)	State University of Campinas	Brazil	Cross-sectional	402	1 Public School and 2 Private School
Roebers & Kauer (2009)	University of Bern	Switzerland	Cross-sectional	112	4 Public School in rural areas
Seitz et al. (2006)	University Children's Hopsital Zurich	Switzerland	Longitudinal	74	Maternity Hopsital Zurich
Wassenberg et al. (2005)	Maastrich University	The Netherlands	Cross-sectional	378	Kindergarten in Maastrich
Planinsec (2002)	University of Maribor	Slovenia	Cross-sectional	665	Kindergarten and others forms of child-care in Maribor and its surroundings

Table 2. Comparison between selected studies

	Bobbio *et al.* (2009)	**Robers & Kauer (2009)**	**Seitz *et al.* (2006)**	**Wassenberg *et al.* (2005)**	**Planinsec (2002)**
Age	6 and 7	7 to 7,6	1st. assessment – 3 2nd. assessment – 6	5 to 6	5 to 6
Sex	Both	Boths	Boths	Boths	Boths
Preterm	No	No	Yes (< 1250g)	No	No
Socioeconomic Status	Public and Pivate school	Public School	Not described property	Not described property	Not described property
Parental Invetigation	Yes	Yes	Yes	Yes	Yes
Previous Therapy	No	No	No	No	No
Informed consent to participate	Yes	Yes	Yes	Yes	Not described property
Standardized testing procedure	Yes (standardized in Brazilian population)	No	Yes (standardized in Switzerland population)	Not to motor function Yes to cognitive function	Yes (standardized in Slovenia population)
Some test details	Using only one test for both functions	Using some tasks from different test	Using one test for motor function and one test for cognitive test	Using qualitative and quantitative measures	Using only one test for both functions
Statistical Analyses	Multinomial Logistic Regression (α=.05)	Not specified Correlation test (α=.01)	Spearman's Correlation test (α=.05)	Linear Regression and Logistic Regression (α=.05)	Multi[le Regression Analyses (α=.05)

Table 3. Testing procedure

	Bobbio *et al.* (2009)	**Robers & Kauer (2009)**	**Seitz *et al.* (2006)**	**Wassenberg *et al.* (2005)**	**Planinsec (2002)**
Motor Function Assessment					
Name	Neurological Evolutional Examination (Lefévre, 1979)	Body Coordination Teste for Children (Kiphard & Schiling, 2002) and M-ABC (Henderson & Sudgen, 1992)	Zurich Neuromotor Assessment- Zurich NMA (Largo et al., 2002)	Maastricht Motor Test – MMT (Kroes et al., 2004)	Not described property
Age Range	3 to 7	Not described	5 to 18	5 to 6	Not described
Standardized on the related population	Yes	Not described	Yes	Yes	Yes
Reliability	Not described	Not described	Yes	Yes	Not described
Number of Tasks	21	4	Not described	70	29
Described each tasks	No	Yes	No	No	No
Motor function category	- Gross and fine motor coordination - visual-motor integration	Not described porperly	- Gross and fine motor coordination - Static and Dynamic Balance	- Static and Dynamic Balance - Ball Skill - Diadochokinesi -Manual Dexterity	- Whole body coordination -Agility - Strength
Described scores	Yes	Yes	Described the score range	Described the score range	No
Described normative scores	Yes	No	No	Yes	No
Cognitive Function Assessment					
Name	Academic Performance Test (Stein, 1994)	Not described property (Zoelch *et al*., 2005; Zimmermman *et al*., 2002; Simmon, 1969)	Kaufman-ABC German version(Melchers, 2001)	VMI (Berry, 1997) and RAKIT (Evers et al. 2000)	Razkol Test (Praper, 1981)
Age Range	Children from 1st.grade to 6th. grade	Not described	Not described	Not described	Not described

Standardized on the related population	Yes	Not described	Yes	Not described	Not described
Reliability	Not described	Not described	Not described	Yes	Not described
Number of Tasks	Not described	4	Not described	27	Not described
Described each tasks	Not described	Yes	Parcial Describition	Parcial Describition	Not described
Cognitive Function category	- Academic performance	Not described	- Experience-independent - Problem-solving - Intellectual capabilities	- Language - Visuoperception - Memory - Construction	- Cognitive function in general
Described scores	Yes	Not described	Not described	Yes	Not described
Described normative scores	Yes	Not described	Not described	Not described	Not described

CAPÍTULO 2

Interlimb Coordination Differentiates Brazilian Children From Two Socioeconomic Settings.

Bobbio TG, Gabbard C, Gonçalves V, Barros Filho A, Morcillo A.

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(ANEXO I)

Short tittle running head: Interlimb Coordination

Interlimb Coordination Differentiates Brazilian Children From Two Socioeconomic Settings

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Abstract

Background: This study tested the notion that Brazilian children entering private school have a motor function advantage over those entering their first year in public school. **Methods**: Four hundred and two (402) children from the two cultural settings were examined for motor function at the first - and ninth month of school (first grade). Participants were assessed based on age-level standards and by total score for all items for children 3- to 7-years of age. **Results**: Results indicated that indeed, the private school group outperformed their public setting peers on the 1st and 2nd assessment; both groups improved over the school year. The most interesting outcome was the type of motor task that most clearly differentiated the groups – activities requiring gross-motor (interlimb) coordination. **Conclusion**: Among the recommendations given, it is suggested that motor skill activities, especially those involving interlimb coordination, be included with any type of motor programming for young children.

Key words: motor skills, early childhood, psychomotor performance.

Motor Function of Brazilian Children Entering Private and Public School

The literature indicates that there is a resurgence of interest in the role of early motor development in overall child behavior. Several studies suggest that early motor behavior plays an important role in social, emotional, and later academic related activities[1-4]. For example, level of fine- and visual-motor ability is associated with daily-living skills[5], movement proficiency[6,7], and cognitive ability[8-10,3].

Research also indicates quite convincingly that some children arrive at school often lacking the motor skills necessary for coping with the demands of a school environment. In some cases the problem is due to lack of experience, and in other cases, perceptual-motor delay or impairment. In addition to the problem with typically developing children, an abundance of evidence shows that children with (for example) Developmental Coordination Disorder (DCD) have an impairment that significantly interferes with daily activities and academic achievement[6,11]. This observation has been reported for an array of motor skills, including fine- and visual-motor ability, gross-motor, performance, and interlimb coordination. Furthermore, studies indicate that children born with low birth-weight often display later problems with motor function, especially fine- and visual-motor integration, and academic performance[12-15].

In an earlier investigation Bobbio et al[16] compared the motor function of Brazilian children entering their first year of school. Of several socioeconomic (SES) factors evaluated, two revealed a significant relationship to motor function: school type (private or public) and prior educational experience (before or after age 4). Motor function was assessed during the first month of school. Results indicated that children entering public school were 5.5 times more likely to have a motor delay, compared to children entering private school. Furthermore, children who started education after age 4 were 2.8 times more likely to display a delay, compared to children who started before age 4. Only 22% of public school children had prior educational experience compared to 90% entering private school. Other study of Brazilian children, compared motor function of children from private and public preschools (5-year-olds) and found that those from the private section displayed a significant fine-motor advantage[17]. In essence, those findings suggest a rather convincing case that children entering private as opposed to public school in Brazil are at a disadvantage in regard to motor function; a problem that we suspect is commonplace in other developing countries and present in parts of many leading nations.

Therefore, the primary goal of the present study was to examine in more detail the hypothesis that Brazilian children from the private sector have an advantage in motor function compared to their public sector peers. Here, we examined children entering private and public first grade. The primary questions were – is there a difference? And, if a difference exists, what specific types of motor function differentiate the two groups? And, after 8 months of schooling, does the private group continue to show an advantage? Given that our work and a multitude of others have established significant differences in SES previously, this report focuses on motor function per se.

Method

Participants and Educational Settings

The study involved 402 children in their first year of elementary school from a large metropolitan city (over 2.5 million inhabitants) in southwest Brazil. For the public school sample, 203 (103 males and 100 females) participants were recruited from a single campus. A similar amount was recruited from two private schools (n = 199, 104 males and 95 females). Ages of the participants recorded during the first-month of the school year were: public school M = 6.5 (SD = .47) years, and the private school M =

6.4 (*SD* = .45) years, with a range of 6.0 to 7.1 years. All participants were volunteers via agreement with the children and parent or guardian. In addition, children with neurological, visual, hearing or mental disorder were excluded. As noted earlier, Bobbio et al.[16] study, significant differences in motor function were strongly associated with private and public school entry, with the advantage for the former. Similar to that study, a general assessment of the present educational settings and evaluation of selected SES factors and prior activity history, confirmed substantial differences. For example, the public school served children in a recognized poverty section of the city that provided free education. Children in the private school lived in higher income housing with parents paying a monthly education tuition of US$600 [the per capita income in Brazil is approximately US$5.000]. To illustrate that difference, the annual income for parents whose children were in the private school was about US$ 30,000.00, compared to US$ 1.800.00 for public school families. Class size for the private school was 35 per class, compared to 40 at the public schools. Interestingly, physical education and art class time were similar. However, one distinctive difference was computer time: two times per week at the private school and no time at the public schools. Table 1 highlights significant SES and activity experience differences favoring children entering private school that have been linked to at-risk children. This research project was approved by the Research Ethics Committee of Medical Science of State University of Campinas.

[Table 1]

Assessment of Motor Function. Motor function was assessed via the Neurological Evolutional Examination (NEE)[18]. The instrument consists of 11 sets of tests designed to assess neurological function in children, aged 3- to 7 years. With the present study, we used 21 selected items from the motor function section that more clearly represented the commonly used classifications: visual-motor integration, fine-motor control, and gross-motor coordination. Four motor development specialists outside of our research group were consulted for proper classification of the 21 items. Based on their input, the gross-motor classification was revised to "interlimb (gross-motor) coordination"; that is, gross-motor action requiring the coordination of both sides of the body. More detail on this subject is provided in a subsequent section.

The tasks are arranged by developmental age and order of complexity. According the test's author, age level items were selected based on 75% performing the activity in a satisfactory manner. Raw scores from each task were converted to scale scores according to the age appropriate norm table. For this study, the motor function score was calculated by summing the 21 scaled scores. The NEE has been reported as a valid and reliable assessment with Brazilian children[19-23]. A single tester whom was trained in NEE administration and reporting conducted assessments.

Procedure

After agreeing to participant, parents completed the family questionnaire. Participants were evaluated with the NEE during the first (February) and tenth month (November) of school. The test was individually administered by a single examiner in an isolated room. Each participant was administered the complete 21 item test beginning at the lowest level (3-year-olds). Two trials were given for each test item. A failing score (F) were applied when the child was unable to achieve the objective, and P for a passing performance.

For the purposes of this study, two measurement methods were used. First, was the more traditional and widely used method - participants that successfully performed the majority of the items for that specific (7-year-old) age level (e.g., 2 out of 3), were classified as 'Passing;' a score less than that was classified as a 'Delay'. Second, for a more comprehensive assessment, we used 'total score' which included all 21 tasks.

Treatment of the Data

We used frequency-data analyses and chi-square procedures to compare children classified as Passing or Delay between school and between first and second assessments. In addition, *t*-test procedure were used to compare SES characteristics and 'total score.' Total score represented the number of items passed out of 21 total tasks. The data analysis was performed with Epi-Info 6.0 (Epidemiology Program Office. Atlanta: Centers for Disease Control, 1994) and SPSS 11.0 (SPSS, Inc, Chicago IL). Statistically significance was set at the p <. 05 level.

Results

Results are presented from a global (overall) perspective, followed by analyses by specific types of task.

1st Assessment

In regard to age-level assessment of those Passing, the values were 80% for the private group and 34% for the public school group, X^2 (1) = 88.0, p <. 01. When considering total score, the private group value was M = 19.7 (SD 1.17) compared to M = 17.8 (SD 1.92) for the public group, t(391)=10.4, p <.01. Regarding, what type(s) of tasks are the public school children having difficulty with? Table 2 shows passing values for the 1st and 2nd assessment by task item and classification (fine-motor, visual-motor, and interlimb coordination). With the generally accepted standard that 75%

passing is acceptable, the public group revealed difficulty with four tasks: one fine-motor, one visual-motor, and two involving interlimb coordination. With the private school group, only one task fell below the standard; it involved interlimb coordination.

[Table 2]

2nd Assessment.

For age-level assessment, values were 96% for the private group and 74% for the public school group, $X^2(1) = 34.5$, $p <. 01$. Total score values were $M = 20.5$ (SD .73) for the private group compared to $M = 19.7$ (SD 1.15) for the public group, $t(290)=6.1$, $p <. 01$. In reference to specific task responses, analyses indicated that the public group had problems with two tasks: one fine-motor and one interlimb coordination. For the private school group, passing rates were above 75% for all 21 test items.

Performance Over Time (1st and 2nd).

In reference to total score, the public group improved significantly from the first assessment, $M = 17.8$ (SD 1.92) compared to $M = 19.7$ (SD 1.15), $t(202)=-11.7$, $p <. 01$. The private group also displayed a significant improvement with values of $M = 19.7$ (SD 1.17) and $M = 20.5$ (SD .73), $t(198)=-6.0$, $p <. 01$. When comparing the amount of improvement, the public school group showed a greater increase, $t(328) = 8.3$, $p <. 001$). In regard to the comparison of group performance by specific task, for the 1st assessment, the private group outperformed their public school peers on eight items: one fine-motor, two visual-motor, and five requiring interlimb coordination (see Table 2). Analysis of the 2nd assessment revealed that the total was reduced to six items: one fine-motor, one visual-motor and four involving interlimb coordination. Interestingly, the public school group did not outperform the private group on any single test item for either assessment.

Discussion

This study was designed to test the hypothesis that Brazilian children entering private school have an advantage over those entering their first year in the public sector. Furthermore, that advantage would be evident by the display of higher levels of motor function. We were also interested in the affect that 8 months of schooling would have on motor function, as well as the type(s) of motor items that differentiate the groups.

As shown in Table 1, there were significant differences in SES backgrounds of the two samples; factors that have been associated with at-risk status and later school performance. For example, parent's income and education, prior educational history, extracurricular activities, and use of computers and video games in the home. In reference to the school setting, although we did not judge the quality of the curriculum and instruction, interestingly, class size was comparable as was physical education time. However, we did note that children in the private sector received more computer time at school, and we could speculate further that this would be the case outside of school.

Our results show clear support for the primary hypothesis that children entering private, as opposed to public school have an advantage in motor function. This finding was evident by the 1st and 2nd assessment results. Using what we believe is a better indicator of overall motor function, total score (using all 21 items), revealed similar results. That is, children in the private setting out-performed their public school peers on both assessments. In regard to the comparison of improvement, both groups did improve over the course of the year school, with the public school group showing better results - 40% compared to 16%; of course, the public school group had a much larger deficit to begin with. Analysis of total score comparisons indicated a similar result, however the magnitude was not as great; score improvement differences were 1.9 for the public school and 0.8 for the private group.

Whereas the result that children entering private school would have an advantage was not surprising, one of our objectives was to determine what specific types of tasks differentiated the groups. Furthermore, it was worth determining what tasks, if any, presented difficulty for the private school group. First of all, we found it quite interesting and somewhat unexpected that the public school group did not outperform the private group on any single test item for either assessment. Arguably, this result provides additional credibility to the advantage notion. Of the three general motor function categories, fine-motor, visual-motor, and interlimb (gross-motor) coordination, the latter highlighted group differences. Five of those tasks separated the groups in the first assessment and four in the second testing. We also wish to note that the only task that the private school group did not have 75% passing involved interlimb coordination. As noted earlier, these actions primarily involve movements requiring sequential and simultaneous use of both sides of the body. More precisely, interlimb coordination involves the timing of locomotor cycles of the limbs in relation to one another[24]. In the context used here, that meant alternating opening and closing hands, alternate tapping finger / foot of one side with the other side, turning hands simultaneously with arms extended, and matching a rhythm with alternating feet tapping. Although basic characteristics of interlimb coordination are displayed by the end of the first year, it appears that considerable improvement occurs from about age 6- to 10 years[25-28].

Obviously, we can only speculate on the factors that may have accounted for the differences between school groups. A view of SES factors (Table 1) and school setting distinctions provide a reasonable hint that the advantage for the private sector population is very likely due to greater 'opportunities [affordances]' for the stimulation of development. For example: developmentally appropriate toys, an earlier start with education, more computer-type activity [related to fine- and visual-motor function), and the likelihood of more supervised and instructed play [perhaps accounting for the gross-motor difference]. Such advantages are more likely with educated parents, which typically provide more household income and knowledge of the need for early education and physical health of the child.

In regard to the implications of this work, our findings have local as well as possible far-reaching implications. Brazil, a developing country, which we suspect is like several others, has a significant disparity between the readiness of children entering school from disadvantaged and higher SES families. The advantage revealed in our data is motor function; a behavior that has been linked to school performance. Certainly, this information should be considered in any general curriculum and motor programming for young children.

In regard to the limitations of this study, a few issues warrant mention. First of all, although reported as valid with Brazilian children. The NEE has limitations in the range of ages (3- to 7 years) for use in elementary school children. For example, some of the 7-year-olds in our study may have tested beyond the age-level assessment. Second, some researchers and practitioners would consider the NEE a test of 'soft' neurological functioning, rather than a more stringent assessment of motor ability.

Nonetheless, our data shows that children entering private first year have a clear advantage in motor function compared to children entering public first grade. Although the public school children displayed significant progress after the school year, the advantage remained with the private setting. Of the motor activities that differentiated the groups, tasks involving interlimb (gross-motor) coordination were most prevalent.

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Table 1

Socioeconomic Characteristics

Variable	*M*	*SD*	Range	*p*
Birth weight, gr				
Public	3111	675.2	1000 – 4750	< .001
Private	3347	664.0	970 - 5100	
Age at Start School, yr				
Public	4.3	1.5	0.04 – 7	< .001
Private	2.3	1.0	0.06 - 6	
Mother's Education, yr				
Public	5.8	2.9	0 – 16	< .001
Private	16.5	2.6	11 - 25	
Father's Education, yr				
Public	5.7	3.3	0 – 19	< .001
Private	16.8	3.0	11 - 25	

Table 2

Percentage of children passing by task item (*- represents 100%)*

	1st			2nd		
	Public	Private	*p*	Public	Private	*p*
Fine-Motor						
1. Touch fingers with tip of the thumb	99	100	.49	-	-	-
2. Make a ball of paper with the dominant hand	98	100	.24	-	-	-
3. Make a ball of paper with the non dominant hand	97	100	.06	-	-	-
4. Replicate rhythmic taps with pencil	46	81	< .01	71	90	< .01
Visual-Motor						
5. Copy an vertical line	-	-	-	-	-	-
6. Build a tower with 9 or more blocks	-	-	-	-	-	-
7. Wind thread onto reel	-	-	-	-	-	-
8. Turn pages of a book	-	-	-	-	-	-
9. Copy a circle	98.5	100	.24	-	-	-
10. Copy a cross	98.5	99.5	.62	-	-	-
11. Copy a square	97.5	100	.06	-	-	-
12. Wind the thread onto reel while walking	86	97.5	< .01	98.5	100	.24
13. Copy a diamond shape	37	77		76	93	< .01
Gross-Motor (Interlimb) Coordination						
14. Beat a rhythm with feet alternately while seated	92	98.5	.003	-	-	-
15. Throw a ball underhand	-	-	-	-	-	-
16. Throw a ball overhand	-	-	-	-	-	-
17. Ball throw for accuracy	-	-	-	-	-	-
18. Make circular motions with the index finger with the arms extended to the side	80	92.5	.0007	92	95.5	.05
19. Alternate opening and closing hands	75	93.5	< .01	92	98.5	.006
20. Alternate tapping finger / foot of one side with the other side	53	85	< .01	81	92.5	.0007
21. With palms facing out, move hands forward and back simultaneously	28	56	< .01	60	84.5	< .01

CAPÍTULO 3

Relationship between motor function and cognitive performance]

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(ANEXO II)

Relationship Between Motor Function and Cognitive Performance

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Abstract

This study examined motor function and its relationship to cognitive ability in 402 Brazilian first-graders. Children were tested for motor function at the first and ninth month and for cognitive ability at the ninth month; average age at the first-month was 6.5 years. Analysis of variance and regression analyses results indicated a strong relationship between motor function and level of cognitive ability (classified as low, average, and high). We observed that the fewer tasks children passed, the lower the cognitive ability level. Analysis by motor task category (fine-, visual-, and gross-motor) revealed that gross-motor activities clearly accounted for the strongest relationship; the risk in being classified with low cognitive ability was about 28 times greater compared to fine-motor, and 50 times greater compared to visual-motor. Interestingly, an evaluation of the gross-motor tasks determined that most could be subcategorized as *interlimb coordination*. That is, movements requiring sequential and simultaneous use of both sides of the body. Overall, these findings support the contention that there is a close interrelation of motor development and cognitive development and early movement experiences maybe an essential agent for developmental change. Furthermore, these results support the need for early detection of children with motor function problems, especially those requiring gross-motor (interlimb) coordination.

Running Title: Motor function and cognitive performance

Key-words: child development; childhood; cognition; learning; motor skills; primary education; psychomotor performance

Relationship Between Motor Function and Cognitive Performance

Over last 25 years, there has been a substantial increase in the presence of motor development research in top tier journals of human development, psychology and neuroscience. This attraction is due in large part to acknowledgement that level of motor development is a critical factor in child behavior [1-4]. Complementing this acknowledgement, the literature indicates that there is a resurgence of interest in the role of early motor development in cognitive ability and academic performance. For example, level of fine- and visual-motor ability is associated with daily-living skills, movement proficiency, and cognitive ability [6-9]. It has been suggested that motor development may act as a 'control parameter' for further development, in that some motor abilities may be a prerequisite for the acquisition or practice of other developmental functions such as perceptual or cognitive ability [10]. Several studies indicate that there is a strong relationship between fine-motor, visual-motor, and cognitive ability [11-14]. Although reports are limited, there are also indications that gross-motor function is a significant predictor of cognitive ability [6]. This particular category of movement was of strong interest in the design of the present study.

In the present study we investigated motor function and its relationship to cognitive performance in Brazilian children during their first year of school. Our interest in this question derives from earlier work in which we examined the motor function of Brazilian first-graders from different socioeconomic settings [15, 16] and found that a large portion of the sample had difficulty with gross-motor tasks requiring interlimb coordination. In fact, the incidence of delay was significantly greater with that group of motor tasks compared to visual- and fine-motor items. Therefore, in addition to the general question of the relationship of motor function to cognitive ability, we were also interested in the specific type of motor activity(s) that maybe an influencing factor.

Children were tested for motor function at the first and ninth month of first-grade and for cognitive ability at the ninth month. The primary questions were – does level of motor function predict academic performance? And, if so, what type of motor task(s) account for the strongest relationship?

The importance of this work relates to the need to identify factors that may contribute or constrain cognitive ability and academic performance in young children. The literature confirms that level of motor function may be a factor. Whereas much has been reported on various cognitive relationships to visual- and fine-motor abilities, little is known concerning gross-motor ability, and more specifically, interlimb coordination. Such information could be helpful in detecting children at risk of developmental delays or disorders.

Method

Participants

The study involved 402 children in their first year of elementary school from a large metropolitan city (over 2.5 million inhabitants) in southwest Brazil. Participants were recruited from a single public school (n = 203, 103 males and 100 females) and a similar amount of children from two private schools (n = 199, 104 males and 95 females). Ages of the participants recorded during the first-month of the school year were M = 6.5 (SD = .47) years, with a range of 6.0 to 7.1 years. All participants were volunteers via agreement with the children and parent or guardian. This project was approved by the Research Ethics Committee.

Assessment of Motor Function.

Motor function was assessed via the Neurological Evolutional Examination (NEE) [17], one of the most widely used tests in Brazil. The instrument consists of 11 sets of tests designed to assess neurological function in children ages 3- to 7 years. For the purposes of this study, we used 21 selected items from the motor function category that more clearly represented visual-motor integration, fine-motor control, and gross-motor coordination.

Fine-motor skills are those movements that usually involve the use of the hands. It refers to movements that require a high degree of control and precision (e.g., writing). Visual-motor skills synchronize visual information with motor movements (e.g., copying figures). And finally, gross-motor activities are primarily controlled by the large muscles such as upper and lower body working together (e.g. walking).

In a previous study using the same NEE items, four internationally known motor development specialists (well-published researchers / physical therapists) outside of our research group were consulted for proper classification of motor function items. Their evaluation identified most of the gross-motor items as requiring a high degree of interlimb coordination – which has in recent years been identified as a subcategory of gross-motor function [18-21]. Interlimb coordination requires sequential and simultaneous use of both sides of the body. What makes interlimb coordination (e.g., tapping hand and foot to a prescribed beat) unique from basic gross-motor function (e.g., walking, jumping) is the degree of 'rhythmicity' involved.

The NEE arranges tasks by developmental age and order of complexity. For this study, the motor function score was calculated by summing the 21 scaled scores. The NEE has been reported as a valid and reliable assessment with Brazilian children [22 - 27].

Assessment of Cognitive Ability.

Cognitive ability was assessed via the *Academic Performance Test* (APT) [28] which consists of three sets of tests: Math, Writing and Reading. The test was designed to evaluate academic performance in children from the first year to the sixth year of school [The author states an age range of below 7 years to above 12 years – however, in Brazil the minimum age for entering first grade is 6.0 years]. The highest possible total score is 143 for all sections: Math (35), Writing (34), and Reading (70). Total score was converted to scale scores according to the grade appropriate norm table. For this study, children were classified using quartiles representing LOW (25% or below), AVERAGE (between 26% and 74%) and HIGH (75% or above). According to the author of the test, the expected mean for children in the first-grade is 51.8 ($\pm$ 38.2). The APT has been reported as a valid and reliable cognitive ability assessment with Brazilian children [29 - 34].

Procedure

Participants were evaluated for motor function at the first month (February) of the school year and for motor function and cognitive ability nine months later (November). Tests were individually administered by a single examiner in an isolated room. The examiner was trained in administering the NEE and APT.

For the NEE, each participant was administered the complete 21 item test beginning at the lowest level (3-year-olds). Two trials were given for each test item. A failing score (F) was applied when the child was unable to achieve the objective, and P for a passing performance, as prescribed by the manual. According to the total score children were divided into two groups by the mean. For the APT, the participants were administered the complete 143 item test. Zero (0) was assigned when the child was unable to achieve the objective of each item, and one (1) was given for a correct performance.

For the purposes of this study, two measurement methods were used for the NEE. First, motor function tasks were divided into fine-motor (4 tasks), visual-motor integration (9 tasks) and gross-motor (8 tasks). The frequency of children (percentage) who passed each task was observed. Second, for a more comprehensive assessment, we used 'total score', which was the number passed out of total items – 21.

Treatment of the Data

All statistical analyses were conducted using SPSS version 13.0 for Windows. Statistical significance was set at the p <. 05 level. One-way analysis of variance (ANOVA) and Tukey post-hoc tests were used to test group differences. In addition, frequency-data analyses and chi-square procedures were used to examine differences between children's cognitive ability (LOW, AVERAGE and HIGH) and the numbers of items passed in each section (Fine-Motor, Visual-Motor and Gross-Motor), as well as Total Score.

For total score, based on the mean for all 402 subjects at the first assessment, 19.0, children were divided into two groups for comparison with cognitive ability: ≤ 19 and ≥ 20.

Next, a multinomial logistic regression was used to examine the association between motor function and cognitive ability. The technique is a generalization of logistic regression to outcomes with more than two levels, which is appropriate here. The dependent variable – cognitive ability, was classified into three categories: LOW, AVERAGE and HIGH. HIGH was selected as the reference category for comparison.

Two sets of analysis were conducted, the first used the first motor function assessment as the independent variable, and the second used the second motor assessment. For ease of interpretation, results are expressed in terms of odds ratios (OR) and 95% confidence interval (CI).

Results

In regard to cognitive ability (total score), 25.5% of children were considered LOW (M = 45.5, SD = 2.7), 55% AVERAGE (M = 52.0, SD = 1.6), and 19.5% in the HIGH (M = 57.9, SD = 1.8) category. The difference between all group means was significant, $F(399) = 998$, $p < .01$.

In reference to motor function, total score (Table I) analysis indicated that there was a significant difference between motor function and cognitive ability in the first and second assessment, $\chi^2(2) = 102.0$, $p < .01$ and $\chi^2(2) = 85.4$, $p < .01$ respectively. For example, with the first assessment, among children that scored at the mean or below for motor function ($\leq$ 19), 41% were classified as LOW cognitive ability and only 12% were classified as HIGH at the first assessment. At the second assessment, the results were similar but the cut point was higher at the second evaluation due to children improved their overall motor function at the second assessment. Among children that scored $\leq$ 19, 43% were classified as LOW and only 11% as HIGH. In other words, a smaller total motor score was associated with a smaller cognitive ability (level).

[Table I]

In regard to motor function category (fine-motor, visual-motor, and gross-motor) analysis indicated significant differences between cognitive ability and fine-motor, $\chi^2(2)$

= 121.2, $p < .01$; visual-motor, $\chi^2(2) = 105.0$, $p < .01$; and, gross-motor function, $\chi^2(2) = 76.3$, $p < .01$ at the first assessment.

Although children improved their overall motor function at the second assessment, results indicated that there were still significant differences between cognitive ability and fine-motor, visual-motor and gross-motor at the second assessment, $\chi^2(2) = 62.9$, $p < .01$; $\chi^2(2) = 56.7$, $p < .01$ and $\chi^2(2) = 68.3$, $p < .01$ respectively. Table II shows passing values for the 1st and 2nd assessments by motor function categories. We observed that the fewer tasks children passed, the lower the cognitive ability level. For example, at the first assessment, 64% children that passed 6 or less tasks were classified as LOW cognitive ability and only 12% were classified as HIGH.

[Table II]

Results of the multinomial logistic regression analyses are shown in Table III. Although the OR was different in each category, the findings indicated that children who passed less motor function tasks were more likely to have a LOW cognitive ability score compared with children who passed more tasks; this was true for both assessments.

In reference to specific motor task category, analyses indicated that gross-motor accounted for the strongest relationship. First assessment data results indicated that children who passed 6 tasks or less were likely (OR = 80) to have LOW cognitive ability than when compared to children who passed all tasks. At the fine-motor category children who passed 3 tasks were more likely (OR = 52.2) to be in the LOW cognitive group compared to children who passed all tasks. Regarding visual-motor, children who passed 3 tasks or less were likely (OR = 29.9) to have LOW cognitive ability compared to children who passed all tasks. Overall, these data suggest that the risk in being classified with LOW cognitive ability was about 28 times greater based on gross-motor function compared to fine-motor, and 50 times greater compared to visual-motor.

[Table III]

Discussion

This study was designed to examine the relationship between motor function and cognitive ability in Brazilian first-graders. If there was a relationship, we were also interested in what type(s) of motor tasks (fine-motor, visual-motor, or gross-motor), account for the association. First of all, the results clearly indicated there was a significant relationship between the two domains. For example, of children that scored at or below the overall motor function total score mean, 41% were classified as LOW cognitive ability and only 12% as HIGH; outcome was similar for the first and second assessment. In essence, from one perspective, motor function predicted cognitive ability.

In reference to our second question – the relationship between type of motor task and cognitive ability, we found significant differences between all three motor categories and cognitive ability. Most interesting however, was the finding that gross-motor function accounted for the strongest association. That is, the data indicated that the risk in being classified with LOW cognitive ability was about 28 times greater based on gross-motor function compared to fine-motor, and 50 times greater compared to visual-motor.

These findings support those reported by Piek et al. [6], whom also found a strong relationship between gross-motor function and cognitive ability. However, an interesting note with our tasks under this category is that each could be subcategorized as *interlimb coordination*. Interlimb coordination primarily involves movements requiring sequential and simultaneous use of both sides of the body. More precisely, interlimb coordination involves the timing of locomotors cycles of the limbs in relation to one another [21]. Although basic characteristics of interlimb coordination are typically displayed by the end of the first year, considerable improvement occurs from about age 6- to 10 years [1, 35-37].

In summary, these findings support the contention that there is a close interrelation of motor and cognitive development. Furthermore, it appears that early movement experiences maybe an essential agent for developmental change. These observations seem to conflict with more traditional notions that motor development begins and ends early, whereas cognitive development begins and ends later. According to Diamond [1], both motor and cognitive development display equally protracted developmental timetables.

The implications of these findings would appear to be in the need for early detection of children with motor function problems that maybe at risk for weak academic performance. That is, with the goal of maximizing potential academic success. This information has practical use in preschool, home, or medical intervention planning. We recommend that any preschool planning or medical intervention should consider motor function activities, and based on our data, activities involving gross-motor, especially interlimb coordination as well as fine- and visual-motor tasks.

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Table I. Cognitive Ability and Motor Function (Total Score)

	Cognitive Ability			
Motor Function	**Low**	**Average**	**High**	χ^2
	n(%)	**n(%)**	**n(%)**	
Total Score (Mean)				
(# items passed)				
1st assessment				
≤ 19 (n = 232)	96(41.3)	108(46.5)	28(12.0)	102.0
20 – 21 (n = 170)	9(3.8)	74(31.8)	87(51.1)	
2nd assessment				
≤ 20 (n = 209)	90(43.3)	92(39.6)	27(11.6)	85.4
21 (n = 193)	15(6.4)	90(38.7)	88(37.9)	

All comparisons significant, *p* <. 01. Percentage appears in parentheses.

Table II. Cognitive Ability and Specific Motor Function Category

	Cognitive Ability			
Motor Function	**Low**	**Average**	**High**	χ^2
1st Assessment	***n* (%)**	***n* (%)**	***n* (%)**	
Fine-Motor (# items passed)				
3 or less	81(54.7)	60(40.5)	7(4.7)	121.2*
4 tasks	24(9.4)	122(48.0)	108(42.5)	
Visual-Motor				
8 or less	87(46.5)	84(44.9)	16(8.5)	105.0*
9 tasks	18(8.3)	98(45.1)	99(46.0)	
Gross-Motor				
6 tasks or less	67(63.8)	50(27.5)	14(12.2)	
7 tasks	34(32.4)	78(42.9)	34(29.6)	104.5*
8 tasks	4(3.8)	54(29.7)	67(58.3)	
2nd Assessment				
Fine-Motor (# items passed)				
3 or less	47(60.2)	26(33.3)	5(6.4)	62.9*
4 tasks	58(17.9)	156(48.1)	110(33.9)	
Visual-Motor				
8 or less	40(63.4)	19(30.1)	4(6.3)	56.7*
9 tasks	65(19.1)	163(48.0)	111(32.7)	
Gross-Motor				
7 tasks	74(47.4)	62(39.7)	20(12.8)	68.3*
8 tasks	31(12.6)	120(48.7)	95(38.6)	

*All comparisons significant, p <. 01. Percentage appears in parentheses.

Table III. Odds Ratios and Confidence Interval from Multinomial Logistic Regression of Cognitive Score

	1st assessment			*2nd assessment*	
	Low vs. High	**Average vs. High**		**Low vs. High**	**Average vs. High**
	OR (CI 95%)	OR (CI 95%)		OR (CI 95%)	OR (CI 95%)
Total Score (Mean)			**Total Score** (Mean)		
19 or less (*n* = 232)	33.3(14.8 – 74.1)**	4.5(2.7 – 7.6) **	20 or less (*n*=209)	19.5(9.7 – 39.2) **	3.3 (1.9 – 5.6) *
20 or more (*n* = 170)	1.00	1.00	21 tasks (*n*=193)	1.00	1.00
Fine-Motor (# items passed)			**Fine-Motor** (# items passed)		
3 or less	52.2 (21.3– 126.7)**	7.5 (3.3 – 17.3) **	3 or less	16.8 (6.7 – 47.2) **	3.6 (1.3 – 9.8) *
4 tasks	1.00	1.00	4 tasks	1.00	1.00
Visual-Motor			**Visual-Motor**		
8 or less	29.9(14.3 – 62.2) **	5.3 (2.9 – 9.6) **	8 or less	15.0(5.8 – 49.9) **	3.2 (1.7 – 9.7) *
9 tasks	1.00	1.00	9 tasks	1.00	1.00
Gross-Motor			**Gross-Motor**		
6 tasks	80.1(25 – 256.1) **	4.4(2.2 – 8.8) **	7 tasks	17.3 (5.9 – 21.4) **	2.4 (1.3 – 4.3) *
7 tasks	16.7 (5.1 – 51.0) **	2.8 (1.6 – 4.8) **	8 tasks	1.00	1.00
8 tasks	1.00	1.00			

OR= odds ratio; CI: confidence interval; ** $p < .01$; * $p < .01$

DISCUSSÃO GERAL

7. DISCUSSÃO

Os achados do presente estudo mostram claramente haver relação entre função motora e desempenho acadêmico. Um baixo escore na função motora indicou estar associado a baixo desempenho acadêmico. Corroborando com os achados de Robers e Kauers (2009) que avaliaram crianças aos 7 anos de idade com desenvolvimento normal e observaram confiável associação entre todas as provas da função motora investigadas com todas as provas da função cognitiva.

Os resultados sustentam as afirmações de íntima relação entre as funções motora e cognitiva e de desenvolvimento concomitantemente dessas funções (Diamond, 2000). Estudos sobre os danos da quimioterapia no tratamento da leucemia em bebês, mostraram que o cerebelo e o córtex pré-frontal foram mais suscetíveis que qualquer outra região do cérebro, evidenciando um período de maturação em conjunto (Ciesielski et al. 1997; Lesnik et al. 1998). Muray et al. (2006) observaram que a maturação do circuito neural básico, envolvido na função motora infantil contribui também para o desenvolvimento do circuito cortical-subcortical envolvido nos processos cognitivos altos.

Entre as crianças com escore menor ou igual à média na função motora, 41% delas apresentaram baixo escore no desempenho acadêmico e apenas 12% apresentaram alto escore. Corroborando com estudos que verificaram que são justamente nas tarefas intelectuais e no desempenho acadêmico que as diferenças entre crianças com e sem dificuldades motoras se tornam evidentes (Holsti et al. 2002; Davis et al. 2007).

A regressão logística multinomial apontou que crianças que passaram em menos provas da função motora tiveram mais chance de terem baixo desempenho acadêmico comparado as crianças que passaram em mais provas.

Estudos demonstram que crianças com pobre planejamento motor geralmente falham ao participar de atividades acadêmicas. Isso ocorre porque o planejamento motor de qualquer comportamento, incluindo tarefas escolares básicas envolve geração de uma idéia e execução de maneira eficiente (Ayres, 1980; Henderson e Hall, 1982; Schaaf et al. 1987; Bar-Haim e Bart 2006).

Diversas pesquisas têm demonstrado que dificuldades motoras, como na coordenação, podem ocasionar dificuldades em atividades essencias requeridas para o sucesso e participação da criança na escola, assim como parte fundamental da auto-estima (Schoemaker e Kalverboer, 1994; Piek et al. 2000; Skinner e Piek, 2001; Rosemblum e Livneh-Zirinski ,2008).

As três categorias da função motora avaliadas no estudo – coordenação motora fina, coordenação motora grossa e coordenação visuo-motora – mostraram associação com desempenho acadêmico. Wassember et al. (2005) e Seitz et al. (2006) também encontraram associação entre as mesmas categorias da função motora investigadas no presente estudo e habilidades cognitivas.

No entanto, a coordenação motora grossa foi a que mostrou mais forte associação com o desempenho acadêmico. O risco de baixo desempenho acadêmico foi maior quando analisadas as provas de coordenação motora grossa comparada às provas de coordenação fina e visuo-motora. Os resultados divergem de estudos que apontam a coordenação motora fina como a de maior influência no desempenho escolar, uma vez que a principal atividade acadêmica, a escrita, envolve a realização de movimentos finos (Volman et al., 2006; Heidrun et al. 2008; Ruiter et al. 2010).

Os achados porém, corroboram Piek et al. (2008) que realizaram um estudo longitudinal para observar se crianças com dificuldade motora também apresentavam atraso no desenvolvimento cognitivo na idade escolar e observaram que a coordenção motora grossa foi a que apresentou mais forte correlação. Murray et al. (2006) em um estudo longitudinal para avaliar associação do desenvolvimento infantil com as conquistas cognitivas no adulto, observaram uma relação entre desenvolvimento motor grosso precoce e boa função executora na idade adulta.

A coordenação motora grossa avaliada no estudo trata-se, mais especificamente, de provas que envolvem a coordenação entre os membros, um subtipo da coordenação motora grossa que vem ganhando importância entre os pesquisadores. Essa coordenação envolve movimentos seqüenciais e uso simultâneo dos dois lados do corpo com alto grau de ritmicidade. Geralmente está dividida em duas categorias: coordenação bimanual e coordenação mãos/pés (Cavalari et al., 2001; Getchell e Whitall, 2003; Getchell, 2006).

No desempenho das habilidades motoras, a coordenação entre os membros é um importante pré-requisito. A maioria dos movimentos diários geralmente envolve a colaboração de ambas as mãos ou mais de um membro ou segmento do corpo. Algumas tarefas como engatinhar ou andar requerem padrões complexos de alternação dos membros. Outras, como agarrar uma bola, envolvem movimentos de ambos os membros simultaneamente em uma correta posição no espaço (Clark et al., 1988; Ehrsson et al., 2000; Salesse et al., 2005).

Comparando os resultados da avaliação motora entre os dois níveis socioeconômicos, representados no estudo pelas escolas da rede publica e da rede privada, as crianças da escola pública apresentaram pior desempenho na função motora na primeira e na segunda avaliação em ambos os escores utilizados no ENE.

Em estudo anterior Bobbio et al. (2007) encontraram as mesmas diferenças entre as escolas que o estudo atual. Os resultados sustentam também os achados de Barros et al. (2003) e Frey e Pinelli (1991) que avaliaram a coordenação motora de crianças de duas classes socioeconômicas diferentes e encontraram diferença significante na coordenação motora entre os dois grupos, apresentando, as crianças com menor renda, escores mais baixos na coordenação.

A desvantagem socioeconômica tem um potente efeito negativo nas habilidades motoras em crianças entre 5 a 8 anos de idade, promovendo um atraso na sua emergência (McPhillips e Jordan-Black, 2007).

Para Gabard (2000) embora os fatores biológicos e o desenvolvimento neurológico ajudem na performance do desenvolvimento motor, os agentes externos, do ambiente, são primeiramente determinantes. Mesmo o desenvolvimento motor sendo dependente e influenciado pela maturação (morfológica, fisiológica e neuromuscular) ele ocorre em um contexto social, tendo o ambiente uma função igualmente importante (Venetsanou e Kambas, 2010).

Teorias recentes que usam o modelo ecológico criado por Bronfenbrenner para descrever o desenvolvimento infantil, acreditam que as características da família (o ambiente do lar e a situação socioeconômica dos pais) afetam a criança porque moldam o ambiente próximo (Magnuson, 2007) e que existe uma ligação interdependente entre o ambiente familiar e o ambiente escolar, que determina o resultado do seu desenvolvimento (Booth e Kelly, 2002; Waanders et al. 2007).

Em estudos relevantes, crianças de baixo nível socioeconômico apresentaram um desempenho inferior ao das crianças de classe média e alta nas baterias de avaliação motora. Dentre as explicações para o pobre desempenho, a falta de experiência, o não encorajamento para desenvolver habilidades como a motora fina útil para os progressos escolares e as pequenas residências desprovidas de espaço adequado para desenvolvimento das habilidades motoras grossas foram as mais apontadas (Bax e Whitmore, 1987; Larsson et al., 1994; Krombholz, 1997; Giagazolgou et al., 2005).

Alguns estudos enfatizam ainda a importância dos fatores de risco biológicos e sociais sobre o desenvolvimento infantil, como idade dos pais, estado civil e nível de escolaridade (Magnuson, 2007; McPhilips e Jordan-Black, 2007;Magnuson, 2009)

Crianças de níveis socioeconômicos mais baixos estão mais expostas a múltiplos fatores de risco (Andraca et al. 1998; Barros, 2003). Esses fatores, sejam quais forem, geralmente não ocorrem de maneira isolada e à medida que se combinam diminui a probabilidade de rendimento da criança. Segundo Bee (2003) a posição socioeconômica em si não determina o desempenho da criança, são seus efeitos na vida familiar que podem fazer a diferença.

Quando comparado os resultados da primeira com a segunda avaliação, foi observada uma melhora no desempenho motor em ambas as escolas. Sendo que a escola pública apresentou um maior percentual de melhora. Tais achados mostram que a escola tem papel importante no processo de desenvolvimento infantil, pois contribui oferecendo um ambiente com os mais diversos estímulos. Esses estímulos são importantes principalmente para a criança de baixa renda que vive, muitas vezes, em um ambiente desprovido deles (Rezende et al. 2005; DeCicca 2007; Welsh et al. 2010).

O programa Head Start iniciado em 1960 nos Estados Unidos, criado para promover apoio escolar para crianças pré-escolares de baixa renda incluindo o envolvimento dos pais, tem sido eficaz em auxiliar essas crianças a ingressar na primeira série com melhor desenvolvimento cognitivo e social (Columbia Electronic Encyclopedia, 2005).

A escola possibilita ao aluno o desenvolvimento de suas possibilidades de ação motora, verbal e mental de forma que possa, posteriormente, intervir no processo sócio-cultural e inovar a sociedade (Mizukami, 1986).

Dentre as categorias da função motora avaliadas, a coordenação entre os membros foi a que mais diferenciou os grupos. Das oito provas relacionadas à coordenação entre os membros, 5 delas foram as que mais apresentaram diferenças entre as escolas na primeira avaliação e 4 delas na segunda avaliação. Além disso, foi uma prova de coordenação entre os membros a única prova que não foi cumprida por no mínimo 75% das crianças da rede privada.

A dificuldade na execução das provas que exigiam coordenação entre os membros pode ter ocorrido porque, embora a coordenação entre os membros se inicie ao final do primeiro ano de vida, o aprimoramento desta coordenação só ocorre entre os 6 e 10 anos de idade (Diamond, 2000).

Em relação às limitações do estudo, o instrumento de avaliação da função motora utilizado, o ENE, foi escolhido após revisão de literatura por avaliar crianças na idade desejada, ser de fácil administração e ter sido padronizado em crianças brasileiras. No entanto, o ENE tem uma limitação da faixa etária de 3 a 7 anos e algumas das crianças avaliadas cursando a primeira série do ensino Fundamental tinham mais de 7 anos. Além disso, os profissionais especializados em desenvolvimento infantil consultados no estudo levantaram a questão do instrumento utilizado ser eficaz para detectar apenas sinais neurológicos leves.

Por haver indícios de que funções motora e cognitiva estão relacionadas, diversos estudos investigam a dificuldade em uma função quando já existe uma dificuldade pré-estabelecida (Spittle et al. 2008). Esta investigação é importante porque algumas das situações que culminam com a dificuldade do desempenho escolar podem estar relacionadas a dificuldades na função motora, pois esta influencia diretamente a função cognitiva das crianças.

Como já descrito, a dificuldade escolar contribui diretamente para os altos índices de repetência e evasão. Dos alunos matriculados no ensino fundamental 1,7 milhões são reprovados sem condições de seguirem para o ensino médio. Segundo dados do INEP

(Instituto Nacional de Estudos e Pesquisas Anísio Teixeira), de cada 100 alunos que ingressam na escola na 1ª. série, apenas 5 concluem o ensino fundamental (Censo INEP, 2008). A preocupação dos educadores atualmente não é apenas com a chegada da criança na escola, mas também, com a permanência nela (Benício, 2005).

Para Chalot (2000) não existe o fracasso escolar, mas sim o aluno em situação de fracasso, a intervenção no processo de dificuldade escolar pode contribuir para diminuição dos índices de evasão.

A investigação do processo evolutivo da criança e de problemas relacionados ao seu desenvolvimento, possibilitam não só a intervenção precoce e implementação de programas de estimulação, mas principalmente, a intenção de enriquecimento do ambiente estimulador (Brêtas et al. 2005).

CONCLUSÃO GERAL

Baseado nos resultados obtidos com o presente estudo permite-se concluir que:

Artigo 1: Segundo evidências na literatura, existe relação direta entre função motora e função cognitiva.

Artigo 2 : Existe diferença na função motora entre crianças de níveis socioeconômicos distintos tanto ao início quanto ao final do ano letivo. Sendo que, as crianças de nível socioeconômico menos favorecido tem menor desempenho na função motora.

Dentre as categorias motoras avaliadas, a que mais diferenciou os grupos foram as provas envolvendo coordenação entre os membros.

Artigo 3: Existe associação entre função motora e desempenho acadêmico. Fraca performance na avaliação da função motora está associada a baixo desempenho acadêmico.

A coordenação entre os membros foi a categoria motora que teve maior associação com o desempenho acadêmico.

CONSIDERAÇÃO FINAL GERAL

Uma vez observada a existência de relação entre função motora e desempenho acadêmico, ao detectar a alteração em uma das funções a outra função também deve ser avaliada.

Além disso, a relação entre elas mostra que a detecção precoce de alterações motoras, assim com intervenção apropriada pode evitar o risco de problemas acadêmicos futuros. Programas de intervenção focados tanto nas funções cognitivas, quanto nas funções motoras na infância podem potencializar os benefícios.

As pré-escolas deveriam considerar a utilização de programas de estimulação infantil, considerando as características individuais de cada criança, com planos de atividades motoras envolvendo coordenação motora grossa, assim como coordenação motora fina e habilidades visuo-motora. Principalmente nas escolas públicas, onde as crianças muitas vezes por falta de estímulos chegam despreparadas ao ensino Fundamental. Isso aumentaria seu potencial de sucesso acadêmico e, conseqüentemente, contribuiria para a diminuição das taxas de evasão e absenteísmo escola.

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Original Article

Interlimb coordination differentiates Brazilian children from two socioeconomic settings

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Abstract ***Background***: The aim of the present study was to test the notion that Brazilian children entering private school have a motor function advantage over those entering their first year in public school.
Methods: Four hundred and two children from the two cultural settings were examined for motor function in the first and 10th month of school (first grade). Participants were assessed based on age-level standards and by total score for all items for children 3 to 7 years of age.
Results: The private school group outperformed their public setting peers on the first and second assessment; both groups improved over the school year. The most interesting outcome was the type of motor task that most clearly differentiated the groups: activities requiring gross motor (interlimb) coordination.
Conclusion: Among the recommendations given, it is suggested that motor skill activities, especially those involving interlimb coordination, be included with any type of motor programming for young children.

Key words early childhood, motor skills, psychomotor performance.

The literature indicates that there is a resurgence of interest in the role of early motor development in overall child behavior. Several studies suggest that early motor behavior plays an important role in social, emotional, and later academic-related activities.[1–4] For example, level of fine and visual motor ability is associated with daily living skills,[5] movement proficiency,[6,7] and cognitive ability.[3,8–10]

Research also indicates that some children start school often lacking the motor skills necessary for coping with the demands of a school environment. In some cases the problem is due to lack of experience, and in other cases, perceptual-motor delay or impairment. In addition to the problem with typically developing children, an abundance of evidence shows that children with, for example, developmental coordination disorder (DCD) have an impairment that significantly interferes with daily activities and academic achievement.[6,11] This observation has been reported for an array of motor skills, including fine and visual motor ability, gross motor, performance, and interlimb coordination. Furthermore, studies indicate that children born with low birthweight often display later problems with motor function, especially fine and visual motor integration, and academic performance.[12–15]

In an earlier investigation Bobbio *et al.* compared the motor function of Brazilian children entering their first year of school.[16] Of several socioeconomic (SES) factors evaluated, two were found to have a significant relationship to motor function: school type (private or public) and prior educational experience (before or after age 4). Motor function was assessed during the first month of school. Results indicated that children entering public school were 5.5-fold more likely to have a motor delay, compared to children entering private school. Furthermore, children who started education after age 4 were 2.8-fold more likely to display a delay, compared to children who started before age 4. Only 22% of public school children had prior educational experience compared to 90% entering private school. Another study of Brazilian children compared motor function of children from private and public preschools (5-year-olds) and found that those from the private institutions had a significant fine motor advantage.[17] In essence, those findings suggest that children entering private as opposed to public school in Brazil are at a disadvantage in regard to motor function; a problem that we suspect is commonplace in other developing countries and present in parts of many leading nations.

The primary goal of the present study was therefore to examine in more detail the hypothesis that Brazilian children from the private sector have an advantage in motor function compared to their public sector peers. Here, we examined children entering private and public first grade. The primary questions were whether there was a difference and, if a difference existed, what specific types of motor function differentiated the two groups; and after 8 months of schooling, whether the private group continued to show an advantage. Given that our work and a multitude of others have established significant differences in SES previously, this report focuses on motor function per se.

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Table 1 Socioeconomic characteristics

Variable	Mean	SD	Range	*P*
Birthweight (g)				
Public	3111	675.2	1000–4750	<0.001
Private	3347	664.0	970–5100	
School starting age (years)				
Public	4.3	1.5	0.04–7	<0.001
Private	2.3	1.0	0.06–6	
Mother's education (years)				
Public	5.8	2.9	0–16	<0.001
Private	16.5	2.6	11–25	
Father's education (years)				
Public	5.7	3.3	0–19	<0.001
Private	16.8	3.0	11–25	

Method

Participants and educational settings

The study involved 402 children in their first year of elementary school from a large metropolitan city (>2.5 million inhabitants) in south-west Brazil. For the public school sample, 203 participants (103 boys, 100 girls) were recruited from a single campus. A similar amount was recruited from two private schools (n = 199, 104 boys, 95 girls). Age of the participants recorded during the first month of the school year was as follows: public school, 6.5 ± 0.47 years; private school, 6.4 ± 0.45 years; range, 6.0–7.1 years. All participants were volunteers via agreement with the children and parent or guardian. In addition, children with neurological, visual, hearing or mental disorder were excluded.

As noted earlier, in the Bobbio *et al.* study, significant differences in motor function were strongly associated with private and public school entry, with the advantage for the former.[16] Similar to that study, a general assessment of the present educational settings and evaluation of selected SES factors and prior activity history, confirmed substantial differences. For example, the public school served children in a recognized poverty section of the city that provided free education. Children in the private school lived in higher income housing with parents paying a monthly education tuition of US$600 (the per capita income in Brazil is approximately US$5000). To illustrate that difference, the annual income for parents whose children were in the private school was approximately US$30 000, compared to US$1800 for public school families. Class size for the private school was 35 per class, compared to 40 at the public schools. Interestingly, physical education and art class time were similar. One distinctive difference, however, was computer time: twice per week at the private school and none at the public schools. Table 1 highlights significant SES and activity experience differences favoring children entering private school that have been linked to at-risk children. This research project was approved by the Research Ethics Committee of Medical Science of State University of Campinas.

Assessment of motor function

Motor function was assessed via the Neurological Evolutional Examination (NEE).[18] The instrument consists of 11 sets of tests designed to assess neurological function in children aged 3–7 years. With the present study, we used 21 selected items from the motor function section that more clearly represented the commonly used classifications: visual motor integration, fine motor control, and gross motor coordination. Four motor development specialists outside of our research group were consulted for proper classification of the 21 items. Based on their input, the gross motor classification was revised to 'interlimb (gross motor) coordination'; that is, gross motor action requiring the coordination of both sides of the body. More detail on this subject is provided in a subsequent section.

The tasks are arranged by developmental age and order of complexity. According the test's author, age level items were selected based on 75% performing the activity in a satisfactory manner. Raw scores from each task were converted to scale scores according to the age-appropriate norm table. For the present study the motor function score was calculated by summing the 21 scaled scores. The NEE has been reported as a valid and reliable assessment with Brazilian children.[19–23] A single tester trained in NEE administration and reporting conducted the assessments.

Procedure

After agreeing to participate, parents completed the family questionnaire. Participants were evaluated with the NEE during the first (February) and 10th month (November) of school. The test was individually administered by a single examiner in an isolated room. Each participant was given the complete 21 item test beginning at the lowest level (3-year-olds). Two trials were given for each test item. A failing score (F) was applied when the child was unable to achieve the objective, and P was used for a passing performance.

For the purposes of the present study two measurement methods were used. First, the more traditional and widely used method: participants who successfully performed the majority of the items for that specific (7-year-old) age level (e.g. two out of three) were classified as 'passing'; a score less than that was classified as a 'delay'. Second, for a more comprehensive assessment, we used 'total score', which included all 21 tasks.

Table 2 Percentage of children passing vs task item

	First assessment		*P*	Second assessment		*P*
	Public	Private		Public	Private	
Fine motor						
1. Touch fingers with tip of the thumb	99	100	0.49	–	–	–
2. Make a ball of paper with the dominant hand	98	100	0.24	–	–	–
3. Make a ball of paper with the non-dominant hand	97	100	0.06	–	–	–
4. Replicate rhythmic taps with pencil	46	81	<0.01	71	90	<0.01
Visual motor						
5. Copy a vertical line	–	–	–	–	–	–
6. Build a tower with nine or more blocks	–	–	–	–	–	–
7. Wind thread onto reel	–	–	–	–	–	–
8. Turn pages of a book	–	–	–	–	–	–
9. Copy a circle	98.5	100	0.24	–	–	–
10. Copy a cross	98.5	99.5	0.62	–	–	–
11. Copy a square	97.5	100	0.06	–	–	–
12. Wind thread onto reel while walking	86	97.5	<0.01	98.5	100	0.24
13. Copy a diamond shape	37	77		76	93	<0.01
Gross motor (interlimb) coordination						
14. Beat a rhythm with feet alternately while seated	92	98.5	0.003	–	–	–
15. Throw a ball underhand	–	–	–	–	–	–
16. Throw a ball overhand	–	–	–	–	–	–
17. Ball throw for accuracy	–	–	–	–	–	–
18. Make circular motions with the index finger with the arms extended to the side	80	92.5	0.0007	92	95.5	0.05
19. Alternate opening and closing hands	75	93.5	<0.01	92	98.5	0.006
20. Alternate tapping finger/foot of one side with the other side	53	85	<0.01	81	92.5	0.0007
21. With palms facing out, move hands forward and back simultaneously	28	56	<0.01	60	84.5	<0.01

–, 100%.

Treatment of the data

We used frequency-data analyses and χ^2 test to compare children classified as passing or delay between school and between first and second assessments. In addition, *t*-test was used to compare SES characteristics and total score. Total score represented the number of items passed out of a total of 21 tasks. The data analysis was performed with Epi-Info 6.0 (Centers for Disease Control, Atlanta, GA, USA) and SPSS version 11.0. (SPSS, Chicago, IL, USA). Statistical significance was set at $P < 0.05$.

Results

Results are presented from a global (overall) perspective, followed by analyses by specific types of task.

First assessment

In regard to age-level assessment of those who passed, this was 80% for the private group and 34% for the public school group ($\chi^2(1) = 88.0$, $P < 0.01$). When considering total score, that for the private group was 19.7 ± 1.17 compared to 17.8 ± 1.92 for the public group ($t(391) = 10.4$, $P < 0.01$). Regarding the question of what type(s) of tasks the public school children had difficulty with, Table 2 lists the passing scores for the first and second assessment versus task item and classification (fine motor, visual motor, and interlimb coordination). With the generally accepted standard that 75% passing is acceptable, the public group was found to have difficulty with four tasks: one fine motor, one visual motor, and two involving interlimb coordination. For the private school group, only one task fell below the standard: this involved interlimb coordination.

Second assessment

For age-level assessment, this was 96% for the private group and 74% for the public school group ($\chi^2(1) = 34.5$, $P < 0.01$). Total score was 20.5 ± 0.73 for the private group compared to 19.7 ± 1.15 for the public group ($t(290) = 6.1$, $P < 0.01$). In reference to specific task responses, analyses indicated that the public group had problems with two tasks: one fine motor and one interlimb coordination. For the private school group, passing rates were >75% for all 21 test items.

Performance over time (first and second assessments)

In reference to total score, the public group improved significantly from the first assessment, 17.8 ± 1.92, compared to 19.7 ± 1.15 for the second assessment ($t(202) = -11.7$, $P < 0.01$). The private group also showed a significant improvement: 19.7 ± 1.17 and 20.5 ± 0.73 ($t(198) = -6.0$, $P < 0.01$). When comparing the amount of improvement, the public school group had a greater increase ($t(328) = 8.3$, $P < 0.001$). In regard to the comparison of group performance versus specific task, for the first assessment the private group outperformed their public school peers on eight items: one fine motor, two visual motor, and five requiring interlimb coordination (Table 2). Analysis of the second assessment showed that the total was reduced to six items: one fine motor, one visual motor and four involving interlimb coordination.

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Interestingly, the public school group did not outperform the private group on any single test item for either assessment.

Discussion

The present study was designed to test the hypothesis that Brazilian children entering private school have an advantage over those entering their first year in the public sector. Furthermore, that advantage would be evident by the display of higher levels of motor function. We were also interested in the affect that 8 months of schooling would have on motor function, as well as the type(s) of motor items that differentiate the groups.

As shown in Table 1, there were significant differences in SES backgrounds of the two samples; factors that have been associated with at-risk status and later school performance. For example, parent's income and education, prior educational history, extracurricular activities, and use of computers and video games in the home. In reference to the school setting, although we did not judge the quality of the curriculum and instruction, interestingly, class size was comparable as was physical education time. We did note, however, that children in the private sector received more computer time at school, and we could speculate further that this would be the case outside of school.

The present results show clear support for the primary hypothesis that children entering private, as opposed to public, school have an advantage in motor function. This finding was evident by the first and second assessment results. Using what we believe is a better indicator of overall motor function, total score (using all 21 items), similar results were found. That is, children in the private setting outperformed their public school peers on both assessments. In regard to the comparison of improvement, both groups did improve over the course of the school year, with the public school group having better results: 40% compared to 16%; of course, the public school group had a much larger deficit to begin with. Analysis of total score comparisons indicated a similar result, but the magnitude was not as great; score improvement differences were 1.9 for the public school and 0.8 for the private group.

Although the result that children entering private school would have an advantage was not surprising, one of our objectives was to determine what specific types of tasks differentiated the groups. Furthermore, it was worth determining what tasks, if any, presented difficulty for the private school group. First of all, we found it interesting and somewhat unexpected that the public school group did not outperform the private group on any single test item for either assessment. Arguably, this result provides additional credibility to the notion of advantage. Of the three general motor function categories, fine motor, visual motor, and interlimb (gross motor) coordination, the latter highlighted group differences. Five of those tasks separated the groups in the first assessment and four in the second testing. We also wish to note that the only task on which the private school group did not have 75% passing involved interlimb coordination. As noted earlier, these actions primarily involve movements requiring sequential and simultaneous use of both sides of the body. More precisely, interlimb coordination involves the timing of locomotor cycles of the limbs in relation to one another.[24] In the context used here, that meant alternating opening and closing hands, alternate tapping finger/foot of one side with the other side, turning hands simultaneously with arms extended, and matching a rhythm with alternating feet tapping. Although basic characteristics of interlimb coordination are displayed by the end of the first year, it appears that considerable improvement occurs from approximately age 6 to 10 years.[25–28]

We can only speculate on the factors that may have accounted for the differences between school groups. An examination of SES factors (Table 1) and school setting distinctions provides a reasonable hint that the advantage for the private sector population is very likely due to greater opportunities (affordances) for the stimulation of development. For example: developmentally appropriate toys, an earlier start with education, more computer-type activity (related to fine and visual motor function), and the likelihood of more supervised and instructed play (perhaps accounting for the gross motor difference). Such advantages are more likely to be associated with educated parents, who typically provide more household income and knowledge of the need for early education and physical health of the child.

In regard to the implications of this work, the present findings have local as well as possible far-reaching implications. Brazil, a developing country, which we suspect is like several others, has a significant disparity between the readiness of children entering school from disadvantaged and higher SES families. The advantage shown in our data is motor function; a behavior that has been linked to school performance. Certainly, this information should be considered in any general curriculum and motor programming for young children.

In regard to the limitations of the present study, a number of issues warrant mention. First of all, although reported as valid with Brazilian children. The NEE has limitations in the age range (3–7 years) for use in elementary school children. For example, some of the 7-year-olds in the present study may have tested beyond the age-level assessment. Second, some researchers and practitioners would consider the NEE a test of 'soft' neurological functioning, rather than a more stringent assessment of motor ability.

Nonetheless, the present data show that children entering private first year have a clear advantage in motor function compared to children entering public first grade. Although the public school children demonstrated significant progress at the second assessment 10 months later, the advantage remained with the private setting. Of the motor activities that differentiated the groups, tasks involving interlimb (gross motor) coordination were most prevalent.

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CORRESPONDENCIA

Relación entre la función motora y el rendimiento cognitivo

Muchos investigadores contemporáneos están de acuerdo en que el nivel de desarrollo motor es un factor crítico en la conducta infantil [1,2]. Como complemento de esta afirmación, hay un resurgimiento del interés por el papel del desarrollo motor precoz en la capacidad cognitiva y el rendimiento académico. Algunos estudios indican que hay una fuerte relación entre la capacidad motora fina, visuomotora y cognitiva [3,4]. Aunque las descripciones que existen son limitadas, también hay indicaciones de que la función motora gruesa es un factor pronóstico significativo de capacidad cognitiva [5]. Esta categoría de movimiento particular fue de gran interés en el diseño del presente estudio.

En este estudio investigamos la función motora y su relación con el rendimiento cognitivo en niños brasileños durante su primer año de colegio. En un estudio previo que también examinaba la función motora de alumnos brasileños en su primer año de escuela primaria, procedentes de diferentes niveles socioeconómicos [6], encontramos que una porción sorprendentemente grande de la muestra presentaba dificultades con las tareas motoras gruesas que requerían la coordinación entre los miembros. De hecho, la incidencia de retraso fue significativamente mayor en ese grupo de tareas motoras en comparación con los ítems visuomotor y motor fino. Por lo tanto, además de la cuestión general de la relación de la función motora con la capacidad cognitiva en niños brasileños en su primer año de escuela primaria, también estábamos interesados en el tipo específico de actividades motoras que puedan ser un factor influyente. Las principales preguntas fueron: ¿el nivel de función motora predice el rendimiento académico? En caso afirmativo, ¿qué tipo de tareas motoras explican la relación más fuerte?

La importancia de este trabajo tiene que ver con la necesidad de identificar factores que puedan contribuir o constreñir la capacidad cognitiva y el rendimiento académicos en niños pequeños. Aunque hay mucha información sobre diferentes relaciones cognitivas con las capacidades visuomotora y motora fina, se sabe poco acerca de la capacidad motora gruesa y, más concretamente, la coordinación entre miembros. Dicha información podría ser útil a la hora de detectar niños con riesgo de padecer retrasos y trastornos del desarrollo.

En el estudio participaron 402 niños que estaban en su primer año de escuela primaria en una gran ciudad metropolitana en el suroeste de Brasil. Los participantes fueron reclutados de un solo colegio público ($n = 203$, 103 niños y 100 niñas) y un número similar de dos colegios privados ($n = 199$, 104 niños y 95 niños). La edad media de los participantes registrados durante el primer mes del curso escolar fue de 6,5 ± 0,47 años (intervalo: 6,0-7,1 años). Todos los participantes eran voluntarios por medio de un acuerdo con los niños y los padres o el tutor. Este proyecto fue aprobado por el Comité Ético de Investigación Clínica.

La función motora se evaluó mediante el examen neurológico evolutivo (ENE) [7], una de las pruebas más utilizadas para los alumnos de primer año de la escuela primaria en Brasil. El ENE consiste en 11 grupos de pruebas diseñados para evaluar la función neurológica en niños de edades comprendidas entre los tres y los siete años. Para los fines de este estudio, utilizamos 21 ítems seleccionados de la categoría de la función motora que más claramente representaban la coordinación visuomotora, motora fina y motora gruesa.

Las capacidades motoras finas son los movimientos producidos predominantemente por los músculos más pequeños del cuerpo y, normalmente, conllevan el uso de las manos. Se refieren a los movimientos que requieren un alto grado de control y precisión (p. ej., escribir). Las capacidades visuomotoras sincronizan la información visual con los movimientos motores (p. ej., copiar cifras). Y, finalmente, las actividades motoras gruesas están controladas principalmente por músculos grandes, como las partes superior e inferior del cuerpo trabajando juntas (p. ej., caminar).

En un estudio previo que utilizó los mismos ítems del ENE, cuatro especialistas del desarrollo motor conocidos internacionalmente (investigadores/fisioterapeutas que han publicado artículos en revistas médicas prestigiosas), ajenos a nuestro grupo de investigación, fueron consultados con el fin de realizar una clasificación adecuada de los ítems de la función motora. Curiosamente, su evaluación identificó que la mayoría de los ítems motores gruesos necesitaba un alto grado de coordinación entre miembros, lo que en los últimos años se ha identificado como una subcategoría de la función motora gruesa [8,9]. La coordinación entre miembros requiere el uso secuencial y simultáneo de los dos lados del cuerpo con un alto grado de 'ritmicidad'.

El ENE organiza las tareas por edad de desarrollo y orden de complejidad. Para este estudio, la puntuación de la función motora se calculó de la suma de las 21 puntuaciones escaladas. El ENE se ha descrito como una evaluación válida y fiable en niños brasileños [10-12].

La capacidad cognitiva se evaluó mediante la prueba de rendimiento académico (PRA) [13], que consiste en tres grupos de pruebas: matemáticas, escritura y lectura. La prueba se diseñó para evaluar el rendimiento académico en niños desde el primero hasta el sexto año de colegio (el autor establece un intervalo de edad de < 7 años hasta > 12 años; sin embargo, en Brasil, la edad mínima para entrar en el primer curso es de 6,2 años). La puntuación total más alta que se puede obtener es 143 para todas las secciones. La puntuación total se transformó en puntuaciones escalares de acuerdo con la tabla de las normas de rendimiento ajustadas al curso. Para este estudio, los niños se clasificaron utilizando los cuartiles 'bajo' (≤ 25%), 'medio' (26-74%) y 'alto' (≥ 75%). Según el autor del texto, la media esperada para niños en el primer año de escuela primaria es de 51,8 ± 38,2. El PRA se ha descrito como una evaluación de la capacidad cognitiva válida y fiable en niños brasileños [14,15].

El primer mes del curso escolar (febrero) se evaluó la función motora de los participantes, y la función motora y la capacidad cognitiva se evaluaron nueve meses más tarde (noviembre). Las pruebas se administraron individualmente por parte de un solo examinador en una sala aislada. Se entrenó al examinador para realizar el ENE y la PRA.

Para el ENE, a cada participante se le administró la prueba completa de 21 ítems empezando en el nivel más bajo (niños de 3 años de edad). Se administraron dos pruebas para cada ítem del examen. Se aplicó una puntuación de suspenso (S) cuando el niño fue incapaz de lograr el objetivo, y una A para un rendimiento aprobado, tal como prescribe el manual. De acuerdo con la puntuación total, los niños se dividieron en dos grupos según la media. Para la PRA, a los participantes se les administró la prueba completa de 143 ítems. Se asignó un 0 cuando el niño era incapaz de lograr el objetivo de cada ítem, y un 1 para una realización correcta.

Con el ENE se utilizaron dos métodos de medición. En primer lugar, las tareas de la función motora se dividieron en motora fina (cuatro tareas), integración visuomotora (nueve tareas) y motora gruesa (ocho tareas). Se observó la frecuencia de niños (porcentaje) que aprobaron cada tarea. En segundo lugar, para una evaluación más completa, utilizamos la 'puntuación total', que era el número aprobado del número total de ítems (21).

Se realizaron análisis estadísticos con el programa SPSS v. 13.0. El análisis de la varianza de un factor (ANOVA) y la prueba post-*hoc* de Tukey se utilizaron para evaluar las diferencias de los grupos en el nivel $p < 0{,}05$. Además, los análisis de los datos y frecuencia y la prueba de χ^2 se utilizaron para examinar las diferencias entre el nivel de capacidad cognitiva de los niños y el número de ítems aprobados en cada sección motora, así como la puntuación total. Para la puntuación total, basada en la media de sujetos en la primera evaluación (19,0), los niños se dividieron en dos grupos para comparar la capacidad cognitiva: ≤ 19 y ≥ 20.

La regresión logística polinomial se utilizó para analizar la asociación entre la función motora y la capacidad cognitiva. La variable dependiente –capacidad cognitiva– se clasificó en los tres niveles con 'alto', elegido como la categoría de referencia para la comparación. Para facilitar la interpretación, los resultados se expresan en términos de oportunidades relativas (*odds ratio*, OR) e intervalo de confianza del 95%.

Con respecto a la capacidad cognitiva (puntuación total), se consideró que el 25% de los niños pertenecía a la categoría baja (45,5 ± 2,7), el 55% a la categoría media (52,0 ± 1,6) y el 19% a la categoría alta (57,9 ± 1,8). La diferencia entre la media de todos los grupos era significativa, $F_{(399)} = 998$; $p < 0{,}01$.

En cuanto a la función motora (puntuación total), el análisis indicó que había una diferencia significativa entre la función motora y la capacidad cognitiva en la primera y la segunda evaluación, $\chi^2_{(2)} = 102{,}0$; $p < 0{,}01$ y $\chi^2_{(2)} = 85{,}4$; $p < 0{,}01$, respectivamente. Por ejemplo, en la primera evaluación, entre los niños que obtuvieron una puntuación igual a la media o inferior para la función motora (≤ 19), el 41% entró en la clasificación de capacidad cognitiva baja y sólo el 12% entró en la clasificación alta en la primera evaluación. En la segunda evaluación, los resultados fueron similares, pero el valor de corte fue más alto debido a la mejora de los niños en su función motora global. Entre los niños que obtuvieron una puntuación ≤ 19, el 43% se clasificó en la categoría baja y sólo el 11% en la categoría alta. En otras palabras, una puntuación total de la función motora más baja estaba asociada a un nivel de capacidad cognitiva más bajo.

Respecto a la categoría de la función motora, el análisis indicó diferencias significativas entre la capacidad cognitiva y la función motora fina, $\chi^2_{(2)} = 121,2$, $p < 0,01$; la función visuomotora, $\chi^2_{(2)} = 105,0$, $p < 0,01$, y la función motora gruesa, $\chi^2_{(2)} = 76,3$, $p < 0,01$ en la primera evaluación.

Aunque los niños mejoraron su función motora global en la segunda evaluación, los resultados indicaban que todavía existían diferencias significativas entre la capacidad cognitiva y la función motora en la segunda evaluación, $\chi^2_{(2)} = 62,9$, $p < 0,01$; $\chi^2_{(2)} = 56,7$, $p < 0,01$, y $\chi^2_{(2)} = 68,3$, $p < 0,01$, respectivamente. Observamos que cuantas menos tareas aprobaban los niños, menor era el nivel de capacidad cognitiva. Por ejemplo, en la primera evaluación, el 64% de los niños que aprobaron seis tareas o menos entró en la clasificación de capacidad cognitiva baja, y sólo el 12% en la clasificación alta.

Los análisis de regresión pusieron de manifiesto que mientras que la OR fue diferente en cada categoría, los resultados indicaron que los niños que aprobaron menos tareas relacionadas con la función motora tenían más probabilidades de obtener una puntuación baja en la capacidad cognitiva en comparación con los niños que aprobaron más tareas; esto fue aplicable para las dos evaluaciones.

En relación con la categoría de tareas motoras específicas, los análisis indicaron que las tareas motoras gruesas explicaban la relación más fuerte. Los resultados de la primera evaluación indicaron que los niños que aprobaron seis tareas o menos tenían probabilidades (OR = 80) de tener una capacidad cognitiva baja en comparación con los niños que aprobaron todas las tareas. En la categoría motora fina, los niños que aprobaron tres tareas tenían más probabilidades (OR = 52,2) de estar en el grupo cognitivo bajo en comparación con los niños que aprobaron todas las tareas. Respecto a la categoría visuomotora, los niños que aprobaron tres tareas o menos tenían más probabilidades (OR = 29,9) de tener una capacidad cognitiva baja en comparación con los niños que aprobaron todas las tareas. En términos generales, estos datos sugieren que el riesgo de ser clasificado en la categoría de capacidad cognitiva baja era unas 28 veces mayor sobre la base de la función motora gruesa comparado con la motora fina, y 50 veces mayor comparado con la visuomotora.

Los resultados indicaron claramente que había una relación significativa entre las dos funciones motoras y el nivel de capacidad cognitiva. Entre los niños que obtuvieron una puntuación igual o inferior a la media de la puntuación total de la función motora global, el 41% entró en la clasificación de capacidad cognitiva baja y sólo el 12% en la clasificación alta; el resultado fue similar para la primera y la segunda evaluación.

Respecto a la relación entre el tipo de tarea motora y la capacidad cognitiva, encontramos diferencias significativas entre las tres categorías motoras y la capacidad cognitiva. Lo más interesante fue el hallazgo de que la función motora gruesa daba cuenta de la asociación más fuerte: el riesgo de ser clasificado en la categoría de capacidad cognitiva baja era unas 28 veces mayor sobre la base de la función motora gruesa comparado con la motora fina, y 50 veces mayor comparado con la visuomotora. Una nota interesante en relación con nuestras tareas en la categoría motora gruesa es que cada una se podría subclasificar como 'coordinación entre miembros'.

Las implicaciones de estos hallazgos parece que se hallan en la necesidad de detectar de forma precoz los niños con problemas de la función motora que puedan estar en riesgo de tener un rendimiento académico débil. Es decir, se trata de maximizar el éxito académico potencial. Esta información tiene un uso práctico en la planificación de la enseñanza preescolar, del hogar o de la intervención médica. Recomendamos que cualquier planificación de la enseñanza preescolar o de la intervención médica tenga en cuenta las actividades de la función motora y, sobre la base de nuestros datos, las actividades que impliquen la función motora gruesa, especialmente, la coordinación entre miembros además de las tareas motora fina y visuomotora.

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Proptosis bilateral paraneoplásica asociada a carcinoma de pulmón

La enfermedad inflamatoria orbitaria o de la órbita (EIO) es una afección común en los adultos, de relevancia en la consulta neurológica o neurooftalmológica por la diversidad de presentaciones clínicas, que incluyen desde una disfunción de la vía visual (defecto pupilar aferente, disminución de la agudeza visual, alteración en la percepción de los colores, defectos en el campo visual), alteración de motilidad ocular (simulando paresia de nervios craneales) o exoftalmia indolora.

Cuando la EIO se presenta de forma silente e insidiosa y con carácter bilateral, comúnmente se asocia a enfermedad sistémica (como enfermedad tiroidea autoinmune, sarcoidosis, enfermedad de Crohn, histiocitosis X, procesos linfoproliferativos, enfermedades del colágeno, metástasis, amiloidosis) o sin causa identificable (inflamación orbitaria idiopática) [1,2]. En la bibliografía hay dos casos descritos de exoftalmos asociados a carcinoma pulmonar [3,4].

Describimos un paciente con desarrollo insidioso de proptosis bilateral y progresiva, co-