OPEN

Surgeon Recommendations for Physical Activity in Patients With Pediatric Hip Conditions

Jacqueline Li, BA,† Emily K. Schaeffer, PhD,*† Stacey Miller, BSc(PT), MRSc,‡§ Verena M. Schreiber, MD,∥ Yasmin D. Hailer, MD, PhD,¶ John C. Clohisy, MD,# Harry K.W. Kim, MD, MS,**†† and Kishore Mulpuri, MBBS, MS(Ortho), MHSc(Epi)*†*

Background: While physical activity (PA) is important during youth, it is unclear if children and adolescents with developmental dysplasia of the hip (DDH), Legg-Calvé-Perthes disease (LCPD), or slipped capital femoral epiphysis (SCFE) are expected or encouraged to return to PA once they have healed. This study examines the orthopaedic surgeons' role in advising pediatric hip patients on the PA they should engage in, assessing their practice, opinions, and consensus when making recommendations.

Methods: Orthopaedic surgeons were invited from member lists of 4 hip study groups. The survey included demographics, opinions regarding PA, and 10 case scenarios that queried respondents on the duration and intensity of PA as well as the restrictions on activity type that they would recommend for DDH, LCPD, or SCFE patients. Consensus was evaluated on a scale ranging from 0 to 1, with a value of 0 indicating no agreement among respondents and a value of 1 indicating complete agreement.

Results: A total of 51 orthopaedic surgeons responded. While 94% agreed that it is important for school-aged hip patients to return to PA after they have healed, 53% believed that PA may compromise the hip and contribute to the development of osteoarthritis. Average standardized consensus was 0.92 for suggesting the patient engage in some amount of PA, 0.44 for suggesting the recommended daily minimum of 60 minutes of moderate-to-vigorous physical activity (MVPA), and 0.33 for suggesting restrictions on activity type. The most frequently selected restrictions included avoiding impact activities (93%, 235/254) and contact activities (58%, 147/254), followed by weight-bearing activities (24%, 62/254). Respondents were not aware of existing PA guidelines, although 57% expressed interest in following guidelines and 39% were uncertain.

Conclusions: While there is consensus among orthopaedic surgeons that children with chronic hip conditions should engage in PA, there is considerable variation when recommending the recommended daily MVPA minimum and placing restrictions on activity type. This study suggests interest among orthopaedic surgeons in developing PA guidelines that optimize outcomes for pediatric hip patients.

Level of Evidence: Level II—Survey study.

Key Words: physical activity, developmental dysplasia of the hip, slipped capital femoral epiphysis, Legg-Calvé-Perthes disease

(*J Pediatr Orthop* 2024;44:468–475)

Developmental dysplasia of the hip (DDH), Legg-Calvé-Perthes disease (LCPD), and slipped capital femoral epiphysis (SCFE) are 3 of the most common pediatric hip conditions. Children and youth diagnosed with these conditions are often restricted in their sports and physical activity participation, which can generally be resumed upon recovery.

Participation in physical activity (PA), defined as "any bodily movement produced by skeletal muscles that results in energy expenditure,"[1] has a variety of important physical and mental health benefits.[2–4] PA is especially important during youth,[5–7] reducing disease risk into adulthood.[8,9] Lifelong PA habits are also potentially established at this time, making it important that regular activity is promoted.[10] The importance of PA in youth is reflected in both national and international guidelines,

From the Departments of *Orthopaedics; ‡Physical Therapy, University of British Columbia; Departments of †Orthopaedic Surgery; §Physiotherapy, BC Children's Hospital, Vancouver, British Columbia, Canada; ¶Section of Orthopaedics, Department of Surgical Sciences, Uppsala University, Uppsala, Sweden; ∥Orthopedic, Sports Medicine and Spine Institute, Nicklaus Children's Hospital, Miami, FL; #Department of Orthopaedic Surgery, Washington University School of Medicine, St. Louis, MO; **Scottish Rite for Children; and ††University of Texas Southwestern Medical Center, Dallas, TX.

This work was partially funded by I'm a HIPpy Foundation, the Peterson Fund for Global Hip Health, and BC Children's Hospital Research Institute.

The authors declare no conflicts of interest.

Reprints: Emily Schaeffer, PhD, Department of Pediatric Orthopaedic Surgery, BC Children's Hospital, 1D.69–4480 Oak Street, Vancouver, British Columbia, Canada V6H 3V4. E-mail: emily.schaeffer@cw.bc.ca.

Supplemental Digital Content is available for this article. Direct URL citations are provided in the HTML and PDF versions of this article on the journal's website, www.pedorthopaedics.com.

DOI: 10.1097/BPO.0000000000002732

which consistently suggest participation in a minimum of 60 minutes of moderate-to-vigorous intensity physical activity (MVPA) each day.[11–13] However, only a third of children and youth in Canada and a quarter in the United States meet their recommended targets.[14,15] While PA likely provides many of the same benefits for youth with healed pediatric hip conditions, the risks remain unclear. In addition, patients may experience functional limitations or require restrictions that add barriers to obtaining optimal levels of PA. Orthopaedic surgeons may play an important role in influencing patients' PA behaviors during the recovery process, which requires further examination.

This study aims to understand orthopaedic surgeons' decision-making when recommending PA to healed, school-aged DDH, LCPD, and SCFE patients. In addition, as there are no known standardized PA guidelines for pediatric hip patients, we wished to determine if there is a need or interest among orthopaedic surgeons in developing guidance.

METHODS

A survey was developed with the input of 3 orthopaedic surgeons and 1 physiotherapist with expertize in pediatric hip conditions. Respondents were first asked questions related to demographics and practice setting. They were then asked to report the frequency with which they make PA recommendations for patients with hip conditions, specifically DDH, LCPD, and SCFE, and identify what factors they consider when making PA rec-

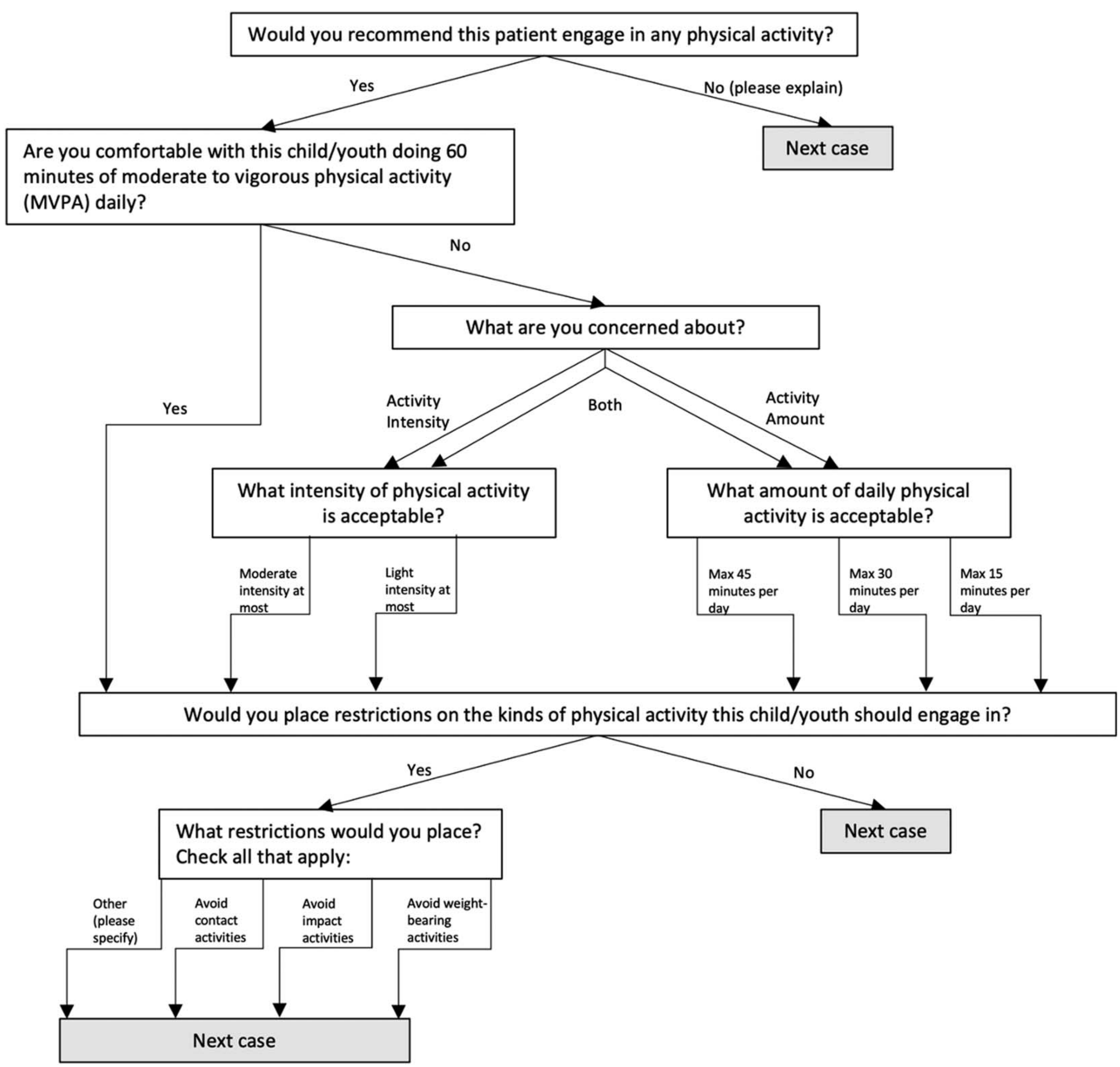

FIGURE 1. Branching logic used for each case scenario.

ommendations. To understand beliefs about PA in relation to pediatric hip conditions, respondents were asked to rate their agreement with a series of 4 statements using a 5-point Likert scale. Respondents were also queried on their awareness of existing PA guidelines, guideline interest, and key stakeholders for guideline development.

Respondents were then presented with ten case scenarios to further explore decision-making. In preparation, a page containing information about the current PA guidelines for children and youth put forth by the Canadian Society for Exercise Physiology, the US Department of Health and Human Services, and the World Health Organization was presented for review.[11–13] Respondents were also provided definitions and examples of different intensities of PA (light, moderate, and vigorous). The case scenarios were selected from the records of a pediatric orthopaedic surgeon practicing in Canada. Cases included patients treated surgically for DDH (4), LCPD (3), and SCFE (3) who were a minimum of 1-year postsurgical intervention, and were chosen to reflect a diverse range of case severity and radiographic outcomes (Appendix 1, Supplemental Digital Content 1, http://links.lww.com/BPO/A760). Diagnosis, age at x-ray, surgical interventions performed, relevant comorbidities, and complications were included. At minimum, 1 postoperative anteroposterior (AP) pelvis radiograph was provided for each scenario; SCFE case scenarios included an additional postoperative frog-leg lateral radiograph. For each case scenario, respondents were asked a series of questions about their recommendations for the post-treatment PA of each patient, assuming they were both healed and pain free, with the branching logic shown in Figure 1. The final question asked respondents to select any PA restrictions they would place, including avoiding contact, impact, and weight-bearing activities. Contact activities include those where there is expected contact with other players, impact activities include those that put increased repetitive stress on weight-bearing joints, and weight-bearing activities include those requiring an individual to support their own body weight.

The survey was developed on the Research Electronic Data Capture (REDCap) platform, a secure web application designed for building and managing online surveys and databases, hosted at the study-coordinating institute.[16,17] Upon approval by the institutional Research Ethics Board, the survey was distributed by e-mail to contact lists of 4 international hip study groups. Responses were anonymized.

Data Analysis

Survey responses were collected on REDCap and analyzed for trends regarding surgeons' opinions and practice. Categorical and ordinal variables were described using percentages and frequencies, while continuous variables were described using mean and range. For the 3 binary questions in the case scenarios, participants were asked to respond "Yes" or "No" to questions about recommending some amount of PA, being comfortable with the patient engaging in 60 minutes of MVPA per day, and suggesting some amount of PA restrictions on activity type. Consensus was standardized on a linear 0 to 1 scale, with a value of 0 indicating 50% consensus (50/50 split between "Yes" and "No") and a value of 1 indicating unanimous consensus (100% "Yes" or 100% "No").

RESULTS

The survey was completed by 51 orthopaedic surgeons from 12 countries. Respondents reported an average practice experience of 15 years (range: 1 to 36 y) and an average 83.6% pediatric caseload. Almost all respondents (96.1%, 49/51) reported completing fellowship training in an orthopaedic subspecialty. Practice characteristics are summarized in Table 1.

Practice and Beliefs about Physical Activity

The frequency with which respondents reported making PA recommendations to all hip patients, those specifically with DDH, SCFE, and LCPD, and important factors to consider when recommending PA are shown in Table 2. Figure 2 shows participants' agreement with statements related to PA in children with hip conditions.

Physical Activity Guidelines

No respondents were aware of pre-existing guidelines for surgeons recommending PA to healed pediatric hip patients. When queried on their interest in following guidelines, 56.9% (29/51) selected "yes," 39.2% (20/51) selected "I don't know," 2.0% (1/51) selected "no," and 2.0% (1/51) selected "other." Of the 29 respondents who expressed interest, all indicated that physiotherapists should be involved in guideline development, followed by orthopaedic surgeons (96.6%), pediatricians/family doctors (51.7%), and occupational therapists (37.9%).

Physical Activity Recommendations Consensus

Table 3 summarizes the results of the 10 case scenarios. Respondents were in favor of recommending some amount of PA in all cases, with "Yes" selected 95.9% of the time (Table 3).

Of the respondents recommending some amount of PA, the majority were comfortable with the specific recommendation of 60 minutes of MVPA per day in all cases (Table 3). Overall, respondents answered "Yes" to this question 72.3% of the time (Table 3).

Those who were uncomfortable with 60 minutes or more of MVPA per day were mostly concerned with both the intensity and amount of PA (73.1%), followed by intensity alone (24.6%) (Table 3). Few respondents (2.3%) were solely uncomfortable with the amount of PA (Table 3). With regards to recommended PA duration, respondents mostly selected a daily maximum of 30 minutes (55.1%, 54/98), followed by 45 minutes (27.6%, 27/98), then 15 minutes (17.3%, 17/98). For the recommended intensity of PA, most selected a maximum of light intensity (59.8%, 76/127), followed by moderate intensity activity (40.2%, 51/127).

When asked if they would suggest some restrictions on activity type, the majority were in favor of suggesting

TABLE 1. Summary of Respondents' Practice Characteristics

Practice location (n = 51), n (%)	
United States	30 (58.8)
India	7 (13.7)
Australia	3 (5.9)
Canada	2 (3.9)
China	2 (3.9)
Germany	1 (2.0)
Sweden	1 (2.0)
Netherlands	1 (2.0)
Malaysia	1 (2.0)
Brazil	1 (2.0)
South Korea	1 (2.0)
United Kingdom	1 (2.0)
Years in practice (n = 50) , n (%)	
0-5	9 (18.0)
6-10	10 (20.0)
11-15	8 (16.0)
16-20	10 (20.0)
21+	13 (26.0)
Orthopaedic subspecialty fellowship training (n = 49), n (%)	
Pediatric orthopaedics	42 (85.7)
Other	7 (14.3)
Pediatric caseload (n = 51), n (%)	
0%-20%	4 (7.8)
21%-40%	1 (2.0)
41%-60%	5 (9.8)
61%-80%	2 (3.9)
81%-100%	39 (76.5)
How many new and follow-up DDH patients do you see in a given year? (n = 51), n (%)	
Never	1 (2.0)
1-20 patients/year	7 (13.7)
21-40 patients/year	7 (13.7)
41-60 patients/year	9 (17.6)
61-80 patients/year	6 (11.8)
> 80 patients/year	21 (41.2)
How many new and follow-up SCFE patients do you see in a given year? (n = 51), n (%)	
Never	0
1-5 patients/year	13 (25.5)
6-10 patients/year	10 (19.6)
11-15 patients/year	12 (23.5)
16-20 patients/year	6 (11.8)
> 20 patients/year	10 (19.6)
How many new and follow-up LCPD patients do you see in a given year? (n = 51), n (%)	
Never	1 (2.0)
1-5 patients/year	10 (19.6)
6-10 patients/year	9 (17.6)
11-15 patients/year	9 (17.6)
16-20 patients/year	8 (15.7)
> 20 patients/year	14 (27.5)

TABLE 2. Summary of Respondents' Practice Characteristics When Recommending PA

Do you discuss a return to physical activity with any of your school-aged (5 to 17 y old) hip patients/families once they have healed? (n = 51), n (%)	
Yes	49 (96.1)
No	2 (3.9)
What percentage of your healed, school-aged (5 to 17 y old) DDH patients/families do you discuss a return to physical activity with? (n = 49), n (%)	
Never	3 (6.1)
0%-25%	2 (4.1)
25%-50%	4 (8.2)
50%-75%	4 (8.2)
> 75%	36 (73.5)
What percentage of your healed, school-aged (5 to 17 y old) SCFE patients/families do you discuss a return to physical activity with? (n = 49), n (%)	
Never	0
0%-25%	1 (2.0)
25%-50%	2 (4.1)
50%-75%	2 (4.1)
> 75%	44 (89.8)
What percentage of your healed, school-aged (5 to 17 y old) LCPD patients/families do you discuss a return to physical activity with? (n = 49), n (%)	
Never	2 (4.1)
0%-25%	0
25%-50%	2 (4.1)
50%-75%	2 (4.1)
> 75%	43 (87.8)
Which of the following factors are important to consider when making physical activity recommendations to healed pediatric hip patients? (n = 51), n (%)	
Patient pain	45 (88.2)
Severity of residual deformity	41 (80.4)
Presence of AVN	42 (82.4)
Current physical health of the patient	37 (72.5)
Patient's previous physical activity before diagnosis	34 (66.7)
Patient's expectation of physical activity	37 (72.5)
I do not know	1 (2.0)
I prefer not to answer	0
Other	2 (3.9)

restrictions in 6 scenarios (Cases 1, 5 to 9) and in favor of no restrictions in 4 (Cases 2 to 4, 10) (Table 3). Overall, respondents selected "Yes" to restrictions 54.0% of the time (Table 3). The most common restriction on activity type was avoiding impact activities (92.5%), followed by avoiding contact (57.9%), and weight-bearing (24.4%) activities (Table 3).

Case Examples

Case 8 was a 15-year-old SCFE patient with a comorbid 2 cm leg length discrepancy who underwent in situ pinning to the right hip at 12 years of age (Fig. 3). This case had the greatest percentage of respondents against some amount of PA, with 6/49 respondents expressing concerns about the likelihood of increasing damage and pain, as many noted existing signs of AVN and OA, mechanical imbalance, and incongruity. This case also had the greatest percentage of respondents who were not comfortable with the recommended 60 minutes of MVPA per day.

Cases 2, 4, and 9 all had unanimous consensus in favor of recommending some amount of PA. These include a 7-year-old DDH patient who underwent bilateral open reduction, pelvic osteotomy, and femoral shortening at age 5 (Fig. 4); a 16-year old DDH patient who underwent an open reduction and right pelvic osteotomy with avascular necrosis at age 5 (Fig. 5); and a 13-year old bilateral SCFE patient who underwent surgical dislocation and left hip osteochondroplasty at age 12 (Fig. 6). While respondents unanimously recommended some amount of PA in all 3 cases, respondents disagreed considerably when asked if they would place restrictions on activity type.

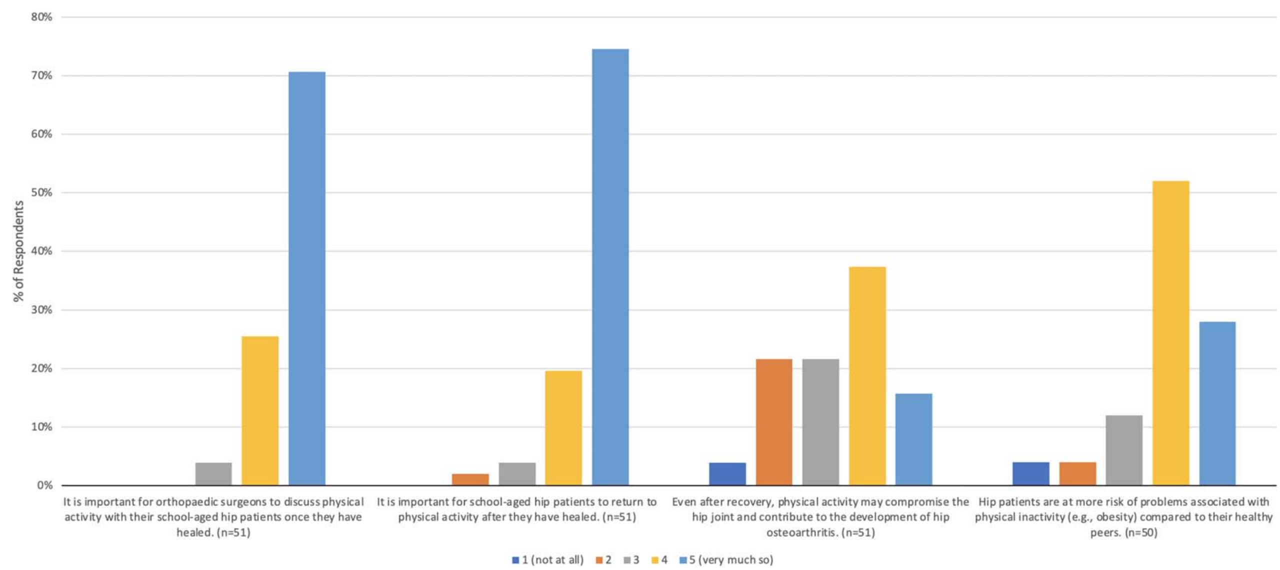

FIGURE 2. Agreement with statements related to PA in children with hip conditions. full color online

Case 10 was a 13-year-old with bilateral SCFE who underwent left hip pinning a year prior and right hip pinning 2 years prior. This case had the greatest percentage of respondents in favor of recommending the full 60 minutes of MVPA per day, as well as the lowest percentage of respondents who would recommend some restrictions on activity type.

DISCUSSION

For children and youth with a hip condition, recommendations made by an orthopaedic surgeon regarding the appropriate duration, intensity, and types of activity are likely to affect their return to PA. An analysis of behaviors and practices with regard to making these recommendations is important, especially for children with mobility restrictions who may experience challenges obtaining optimal PA levels. This survey demonstrates that orthopaedic surgeons regard PA as an essential component of the recovery process for children with hip conditions. Specifically, 94% indicated that school-aged DDH, SCFE, and LCPD patients need to return to PA after they have healed. The survey also confirmed that orthopaedic surgeons play an active role in recommending PA, as the majority of respondents reported frequently discussing a return to PA with their patients across all 3 hip disorders.

The case scenarios demonstrate clear support among orthopaedic surgeons for pediatric hip patients to engage in some amount of PA. However, even among this group of hip experts, there is still substantial practice variation with regards to recommending 60 minutes of MVPA per day, which has been consistently supported by national and international organizations for youth to derive health benefits.[11–13] The lack of consensus reflects an inadequate understanding of PA and its impact on youth with hip conditions. Those recommending against some amount of PA commonly noted worries about further damage and increased risk of injury, which may be concerns shared with respondents who recommended some amount of PA

TABLE 3. Response Frequencies, Percentages, and Average Standardized Consensus for the 10 Case Scenarios

Case Number	1	2	3	4	5	6	7	8	9	10	Overall
Condition	DDH	DDH	DDH	DDH	LCPD	LCPD	LCPD	SCFE	SCFE	SCFE	
Some PA (Yes/No)	46/49	49/49	48/49	49/49	47/49	46/49	46/49	43/49	49/49	47/49	470/490
Standardized consensus	0.878	1	0.959	1	0.918	0.878	0.878	0.755	1	0.918	0.918
60 minutes of MVPA daily (Yes/No)	28/46	38/49	40/48	38/49	33/47	29/46	31/46	25/43	34/49	44/47	340/470
Standardized consensus	0.217	0.551	0.667	0.551	0.404	0.261	0.348	0.163	0.388	0.872	0.442
Concerned with recommendation-intensity	6/18	2/11	3/8	2/11	4/14	5/17	2/15	2/18	4/15	2/3	32/130
Concerned with recommendation-amount	0/18	0/11	0/8	0/11	0/14	0/17	1/15	0/18	2/15	0/3	3/130
Concerned with recommendation-both	12/18	9/11	5/8	9/11	10/14	12/17	12/15	16/18	9/15	1/3	95/130
Restrictions on activity type (Yes/No)	33/46	23/49	15/48	21/49	28/47	36/46	32/46	30/43	27/49	9/47	254/470
Standardized consensus	0.435	0.0612	0.375	0.143	0.191	0.565	0.391	0.395	0.102	0.617	0.328
Avoid contact activities	21/33	12/23	5/15	9/21	14/28	21/36	20/32	25/30	16/27	4/9	147/254
Avoid impact activities	31/33	22/23	13/15	19/21	26/28	34/36	31/32	28/30	22/27	9/9	235/254
Avoid weight-bearing activities	5/33	8/23	2/15	6/21	5/28	10/36	11/32	10/30	4/27	1/9	62/254
Other	2/33	3/23	4/15	3/21	1/28	2/36	3/32	1/30	4/27	1/9	24/254

FIGURE 3. Radiographs of a 15-year-old female SCFE patient in Case 8, with both anteroposterior (left) and frog-leg lateral (right) radiographs taken 3 years postoperatively.

albeit with modifications. Observed radiographic features leading to perceptions about patient pain and other symptoms may also have led respondents to make more restrictive recommendations. Alternatively, some respondents may have chosen to be less restrictive if they had no concerns or if they believed that the health benefits of following PA guidelines outweighed the potential risks. For example, SCFE patients, who are often more overweight than their peers, may particularly benefit from PA.[18]

Respondents achieved the lowest average standardized consensus when asked if they would suggest restrictions on activity type, recommending restrictions approximately half of the time. This suggests greater concern about the kinds of activities that patients engage in, especially impact activities, as opposed to duration and intensity. Concerns regarding activity type may include increased risk of acute injuries to the hip with contact sports, as well as repetitive joint-loading with high impact and, to a lesser extent, weight-bearing activities, causing surgeons to limit participation in these activities. Certain

FIGURE 4. Radiographs of a 7-year-old female DDH patient taken preoperatively (left) and 2 years postoperatively (right).

FIGURE 5. Anteroposterior radiograph of a 16-year-old female DDH patient taken 11 years postoperatively.

impact sports have specifically been associated with an increased risk of hip osteoarthritis (OA) and cam deformity, albeit mainly in high-level male athletes.[19,20] A recent study by Leopold et al[21] found a shift in DDH patients' PA behaviors after periacetabular osteotomy (PAO)—although activity levels increased with regard to frequency and duration, patients changed to more low-impact sports participation, suggesting shared concerns about such activities.

Another contentious topic among respondents was the relationship between PA and hip OA. While increased risk of hip OA progression has been observed in elite athletes, it is not consistently observed in individuals who engage in normal levels of PA, including those with existing joint pathology.[20,22,23] In fact, PA is often encouraged as a therapeutic treatment for OA to improve symptoms and physical function.[23,24] The benefits and drawbacks of PA may be complicated in hip patients, who are at greater risk of developing OA secondary to their condition.[25–27] Few studies have examined this relation-

FIGURE 6. Frog-leg lateral (left) and anteroposterior (right) radiographs of a bilateral 13-year-old female SCFE patient taken 1-year postoperatively.

ship, with a single study by Hara et al,[28] demonstrating that postoperative participation in sports after PAO has no effect on OA progression. In contrast, a study by Matheney et al[29] found that DDH patients with higher activity levels presented earlier for hip preservation surgery, suggesting that increased activity levels may lead to earlier presentation of arthrosis. However, it must be noted that many factors may lead a patient to seek surgery at earlier ages, with studies demonstrating a general trend toward decreasing age at presentation for total hip replacements over recent decades.[30,31] Further investigation is needed to understand the long-term effects of preoperative and postoperative PA in this population and its potential dose-dependent effects on hip health.

Even among a group of experts, there is clear variation in practice and opinion when making recommendations for PA in patients with healed pediatric hip conditions. Existing PA guidelines provide only broad guidance—children and youth with different physical capabilities and impairments, such as those with hip conditions, require greater support. To our knowledge, there are no PA guidelines developed specifically for pediatric patients with hip conditions. Over half of the survey respondents were interested in following standardized PA guidelines, which would decrease practice variation and lead to improved patient outcomes, ensuring that both overall health and hip health are maximized in the long term. However, should guidelines be developed, they will need to consider a plethora of individualized patient factors in order to provide appropriate recommendations for the amount, intensity, frequency, and restrictions on activity type. Both hip and nonhip-related factors must be evaluated, including existing pain or other symptoms, severity of residual deformity, and the patients' own expectations.

Further study of PA in children and youth with pediatric hip conditions is required to inform surgeon decision-making and potential future guidelines. There is currently limited research in this area. A 2021 study of 28 children with hip conditions by Leo et al[32] found that 70% experienced some degree of physical limitations. Despite this, the average daily MVPA of the sample exceeded recommended targets; however, the study sustained a low sample size collected from a single institution, and participants were mainly LCPD patients who have been previously found to be more hyperactive that their healthy peers.[32,33] Thus, multicenter, longitudinal studies are needed to collect data on the intensity, frequency, and types of PA that patients participate in, as well patient-important outcomes that may include variables such as pain and satisfaction with return to activity. Surveys of other relevant health care providers who were identified in this study, particularly physiotherapists, may also help to identify practice variation in other fields and inform successful guideline development.

This study had several limitations. While many different countries were represented internationally in this survey, most respondents reported practicing in developed countries with more advanced health care and education systems, and thus may hold a shared perspective. In addition, respondents mainly consisted of pediatric hip experts belonging to major prospective study groups, whose opinions and decision-making may not be reflective of other surgeons. Surveys are also inherently limited in their ability to analyze surgeon practice—although respondents were provided with standard patient information, there are many nuances during real-life decision-making that could not be captured. The case scenarios specifically were also open to interpretation based on the limited information provided. Some information that was not provided to respondents include a frog-leg lateral view for the LCPD cases, which may have been beneficial when making PA recommendations. Finally, the limited number of patient case scenarios in each disease group prevented the analysis of associations between case factors (eg, disease severity) and consensus level or between-group comparisons, which are 2 areas of potential future study.

CONCLUSION

Despite orthopaedic surgeons' role in influencing their patients' PA behavior, there is no consensus on the duration, intensity, and types of activity restrictions to recommend. This study will hopefully start the conversation about the need for further research to better understand the PA behaviors of healed pediatric hip patients, as well as the development of PA guidelines that optimize patient outcomes.

ACKNOWLEDGMENTS

The authors thank the survey participants belonging to the Global Hip Dysplasia Registry (GHDR), the International Perthes Study Group (IPSG), the SCFE Longitudinal International Prospective Registry (SLIP), and the Academic Network of Conservational Hip Outcomes Research (ANCHOR).

REFERENCES

1. Caspersen CJ, Powell KE, Christenson GM. Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public Health Rep*. 1985;100:126–131.
2. Anokye NK, Trueman P, Green C, et al. Physical activity and health related quality of life. *BMC Public Health*. 2012;12:624.
3. Penedo FJ, Dahn JR. Exercise and well-being: a review of mental and physical health benefits associated with physical activity. *Curr Opin Psychiatry*. 2005;18:189–193.
4. Warburton DE, Nicol CW, Bredin SS. Health benefits of physical activity: the evidence. *CMAJ*. 2006;174:801–809.
5. Janssen I, Leblanc AG. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *Int J Behav Nutr Phys Act*. 2010;7:40.
6. Marker AM, Steele RG, Noser AE. Physical activity and health-related quality of life in children and adolescents: a systematic review and meta-analysis. *Health Psychol*. 2018;37:893–903.
7. Poitras VJ, Gray CE, Borghese MM, et al. Systematic review of the relationships between objectively measured physical activity and health indicators in school-aged children and youth. *Appl Physiol Nutr Metab*. 2016;41(suppl 3):S197–S239.
8. Kallio P, Pahkala K, Heinonen OJ, et al. Physical inactivity from youth to adulthood and adult cardiometabolic risk profile. *Prev Med*. 2021;145:106433.
9. Jacka FN, Pasco JA, Williams LJ, et al. Lower levels of physical activity in childhood associated with adult depression. *J Sci Med*

Sport. 2011;14:222–226.
10. Telama R, Yang X, Viikari J, et al. Physical activity from childhood to adulthood: a 21-year tracking study. *Am J Prev Med*. 2005;28: 267–273.
11. Bull FC, Al-Ansari SS, Biddle S, et al. World Health Organization 2020 guidelines on physical activity and sedentary behaviour. *Br J Sports Med*. 2020;54:1451–1462.
12. Piercy KL, Troiano RP, Ballard RM, et al. The Physical Activity Guidelines for Americans. *JAMA*. 2018;320:2020–2028.
13. Tremblay MS, Carson V, Chaput JP, et al. Canadian 24-hour movement guidelines for children and youth: an integration of physical activity, sedentary behaviour, and sleep. *Appl Physiol Nutr Metab*. 2016;41(suppl 3):S311–S327.
14. Friel CP, Duran AT, Shechter A, et al. US Children Meeting Physical Activity, Screen Time, and Sleep Guidelines. *Am J Prev Med*. 2020;59:513–521.
15. Roberts KC, Yao X, Carson V, et al. Meeting the *Canadian 24-Hour Movement Guidelines for Children and Youth*. *Health Rep*. 2017;28: 3–7.
16. Harris PA, Taylor R, Thielke R, et al. Research electronic data capture (REDCap)–a metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform*. 2009;42:377–381.
17. Harris PA, Taylor R, Minor BL, et al. The REDCap consortium: Building an international community of software platform partners. *J Biomed Inform*. 2019;95:103208.
18. Perry DC, Metcalfe D, Lane S, et al. Childhood obesity and slipped capital femoral epiphysis. *Pediatrics*. 2018;142:e20181067.
19. Nepple JJ, Vigdorchik JM, Clohisy JC. What is the association between sports participation and the development of proximal femoral cam deformity? A systematic review and meta-analysis. *Am J Sports Med*. 2015;43:2833–2840.
20. Vigdorchik JM, Nepple JJ, Eftekhary N, et al. What is the association of elite sporting activities with the development of hip osteoarthritis? *Am J Sports Med*. 2017;45:961–964.
21. Leopold VJ, Szarek A, Hipfl C, Pumberger M, Perka C, Hardt S, Löchel J, et al. Changes in Sports Activity After Periacetabular Osteotomy: A Qualitative and Quantitative Analysis. *Am J Sports Med*. 2023;51:481–486.
22. Lefèvre-Colau MM, Nguyen C, Haddad R, et al. Is physical activity, practiced as recommended for health benefit, a risk factor for osteoarthritis? *Ann Phys Rehabil Med*. 2016;59:196–206.
23. Kraus VB, Sprow K, Powell KE, et al. Effects of physical activity in knee and hip osteoarthritis: a systematic umbrella review. *Med Sci Sports Exerc*. 2019;51:1324–1339.
24. Fransen M, McConnell S, Hernandez-Molina G, et al. Exercise for osteoarthritis of the hip. *Cochrane Database Syst Rev*. 2014: CD007912. doi:10.1002/14651858.CD007912.pub2
25. Castañeda P, Ponce C, Villareal G, et al. The natural history of osteoarthritis after a slipped capital femoral epiphysis/the pistol grip deformity. *J Pediatr Orthop*. 2013;33(suppl 1):S76–S82.
26. Heesakkers N, van Kempen R, Feith R, et al. The long-term prognosis of Legg-Calvé-Perthes disease: a historical prospective study with a median follow-up of forty one years. *Int Orthop*. 2015; 39:859–863.
27. Jacobsen S, Sonne-Holm S. Hip dysplasia: a significant risk factor for the development of hip osteoarthritis. A cross-sectional survey. *Rheumatology (Oxford)*. 2005;44:211–218.
28. Hara D, Hamai S, Fukushi JI, et al. Does participation in sports affect osteoarthritic progression after periacetabular osteotomy? *Am J Sports Med*. 2017;45:2468–2475.
29. Matheney T, Zaltz I, Kim YJ, et al. Activity level and severity of dysplasia predict age at bernese periacetabular osteotomy for symptomatic hip dysplasia. *J Bone Joint Surg Am*. 2016;98:665–671.
30. Hilibrand AS, Rubin LE, Grauer JN. Geographic variations and trends in primary and revision knee and total hip arthroplasties in the United States. *JB JS Open Access*. 2020;5:e0051
31. Sloan M, Sheth N Changing Demographics in Primary and Revision Total Joint Arthroplasty, 2000-2014. Paper presented at: 2018 AAOS Annual Meeting; 2018; New Orleans, LA. Accessed February 23, 2023. http://submissions.mirasmart.com/Verify/AAOS2018/Submission/out/AAOS2018-005902.PDF.
32. Leo DG, Perry DC, Abdullah B, et al. PROMIS Paediatric Mobility tool is correlated with accelerometer-measured physical activity in children with hip diseases. *Bone Joint J*. 2021;103-B:405–410.
33. Hailer YD, Haag AC, Nilsson O. Legg-Calvé-perthes disease: quality of life, physical activity, and behavior pattern. *J Pediatr Orthop*. 2014;34:514–521.

