Original article

Demographics and rates of surgical arthroscopy and postoperative rehabilitative preferences of arthroscopists from the Arthroscopy Association of North America (AANA)

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ABSTRACT

Survey of 869 arthroscopists regarding joint-specific arthroscopic procedures and postoperative rehabilitative preferences revealed comparable support for use of supervised physical therapy (SPT) and home exercise programs (HEPs) but stronger preference for joint-specific HEP applications (wrist, knee). Among respondents utilizing HEPs, modality of delivery (verbal/handout/web-based) didn't differ by joint, yet only 2.9% utilized web-based HEPs. This is the first known study to identify postoperative rehabilitation preferences. With 1.77 million estimated arthroscopic procedures annually (mean: 325.4 procedures/respondent), this study highlights under-utilization of web-based HEPs. Reliable, web-based HEPs can improve post-arthroscopic outcomes for patients, arthroscopic surgeons, and rehabilitative specialists while being cost efficient.

1. Introduction

Surgical arthroscopy is a well-established treatment option for patients suffering from persistent joint pain and dysfunction. Compared to open-joint surgeries, arthroscopy is minimally-invasive and boasts greater overall patient outcomes with respect to symptom relief, duration of hospital stay, structural recovery, and long-term results.^{1,2} However, the number of joint-specific arthroscopic procedures performed annually is not well-documented in the literature.

A major component of patient satisfaction following such procedures is likely attributable to the functional improvements patients experience following post-surgical rehabilitation therapy. In a randomized controlled trial, Moffet et al.³ found that patients receiving physiotherapy treatment had a significant increase in knee extensor strength, nearly 26% more than the control group. However, some practitioners believe that there is little substantive evidence to confirm the use of rehabilitation protocols.⁴

Within the literature, there is no consensus as to whether well-planned home exercise programs (HEPs) can be just as effective as supervised physical therapy (SPT) in achieving functional postoperative

recovery of the joint. Recently, Austin et al.⁵ found that patients treated with HEPs after total hip arthroplasty (THA) experienced the same improvements in function and quality of life compared to patients undergoing SPT. Yet other studies have found that SPT can lead to significantly improved overall functioning of the affected joint following arthroscopy when compared to HEPs.^{6,7}

Given the conflicting evidence, this study seeks to compare the preferences and beliefs of arthroscopic surgeons in the utility and benefits of postoperative home exercise programs (HEPs) and supervised physical therapy (SPT). This study also aims to obtain a quantifiable estimate of the number of arthroscopic surgeries performed around the United States and abroad, and to analyze how its application varies by region.

2. Methods

The Arthroscopy Association of North America (AANA) is an international non-profit organization of orthopaedic surgeons committed to advancing the field of arthroscopic surgery. 7200 electronic, Google-based surveys consisting of questions pertaining to post-arthroscopic

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rehabilitation philosophies were distributed to AANA members and results were received from April 3, 2017 to May 21, 2017. These surveys collected surgeons' demographical information and postoperative rehabilitation therapy beliefs across all arthroscopic joint disciplines. Also collected was information regarding the number of surgeries performed by each individual surgeon, while in addition, questioning arthroscopists on their mode of conveyance for home exercise regimen recommendations. Surgeons were instructed to only complete survey questions related to surgeries of the specific joints they perform. This study was deemed exempt by the Institutional Review Board (IRB) due to the de-identified nature of the data.

2.1. Demographics

Of the 869 surgeons who completed the survey, the highest proportion (35%) were between the ages of 36 and 45 years, while only 7% reported an age < 35 years (29% 46–55 years; 29% > 55 years). The majority (46%) of respondents reported > 16 years in practice (18% 0–5 years, 19% 6–10 years, and 17% 11–15 years). The survey extended beyond surgeons practicing in the United States to those practicing internationally. Internet Protocol (IP) addresses and zip codes were obtained from the survey group to localize respondents' region of practice. For those who failed to provide zip codes, IP addresses were utilized to aid localization efforts. The majority of respondents were in a group practice with other orthopaedic surgeons.

2.2. Statistical analysis

Survey results were transferred to spreadsheets using Microsoft Excel 2010 software (Microsoft Corporation, Redmond, WA, USA) and analyzed. Responses were tallied and percentages were calculated for each of the following groups: arthroscopists who preferred post-arthroscopic SPT rehabilitation and those who preferred HEP rehabilitation. Joint-specific survey data were compared by involved joint: shoulder, elbow, wrist, hip, knee, and ankle. Surgeons who referred patients for HEPs were further questioned on the setting in which recommendations are given (office, PT facility, or other) and methodology of conveyance (web-based, verbally conveyed, or by handouts) of such regimens. Chi-square analysis was employed to identify any significant differences between respondents.

Nominal data was also gathered from this study, with intention to estimate the annual number of arthroscopic surgeries performed across the United States (US). Survey respondents could free-text the number of arthroscopies performed each year for each joint. Given the free-text feature, certain inputs (e.g. number ranges or responses including terms such as “more than” or “greater than”) were adjusted prior to analysis. For example, nominal data that included phrases such as “more than” etc., the number value provided was used for analysis (e.g. if more than 200, 200 was used). The means and standard deviations were also calculated for ranged nominal data (e.g. 50–100, we used 75). Sums were calculated and data was geographically regionalized by utilizing the official Census Division and Regions Map of the United States provided by the United States Census Bureau.⁸ These sums were then extrapolated, assuming similar distribution patterns obtained in the study and full compliance from survey respondents. The mean number

of arthroscopies performed was determined and regionally separated; significant differences were determined by employing analysis of variance (ANOVA).

Statistical analyses were performed using Microsoft Excel and SPSS software version 23.0 2017 (IBM Corporation, Armonk, NY, USA). All p-values were two-tailed; $p < 0.05$ was established as the threshold for statistical significance. All tables were generated using Microsoft Word 2010 (Microsoft Corporation, Redmond, WA, USA).

3. Results

3.1. Supervised physical therapy and home exercise programs

Our survey found that comparable proportions of respondents believed in the utilization of post-arthroscopic SPT and HEP (SPT: 91.5% of 869 surgeons vs. HEP: 94.4% of 858 surgeons; $p = 0.063$). When comparing these preferences among arthroscopists by joint-specific practices, a significant difference was identified between SPT and HEP utilization among wrist (SPT: 71.88% [$n = 32$] vs. HEP: 96.55% [$n = 29$]; $p = 0.009$) and knee (SPT: 88.47% [$n = 92$] vs. HEP: 95.53% [$n = 92$]; $p = 0.0017$) specialists. No such differences were found between shoulder ($p = 0.238$), elbow ($p = 0.221$), hip ($p = 0.094$), or ankle ($p = 0.467$) specialists. There was a significant difference in the belief in utilizing supervised physical therapy when comparing each of the joint surgeries ($p < 0.001$). However, this was not the case when comparing the surgeries by joint with respect to belief in HEP utility ($p = 0.182$) (Table 1).

When evaluating HEPs specifically, the survey identified that different strategies were employed when offering post-arthroscopic HEP instruction to patients. Half of the respondents in the survey provided instructions directly from their office; the majority of the other half of respondents had physical therapists offer instruction. Surgeons also conveyed rehabilitation instructions in variety of ways, with the 61.4% of respondents providing instructions by means of handouts and 31.9% offering instructions verbally. Only 2.9% indicated that they utilized a website for this purpose. No significant difference was identified with respect to selected mode of conveying instructions when comparing each joint surgery group ($p = 0.058$) (Table 2).

3.2. Arthroscopy by geographic distribution

The annual number of arthroscopic procedures in the US was predicted to be 1.77 million. Survey responses were received from 244 US-based orthopaedic surgeons who reported performing an estimated total of 79,395 arthroscopies annually (mean = 325.4). Responses were subsequently separated by regional reporting, and surgeons from the South ($n = 102$) were found to have performed the highest number of surgeries (mean = 354.3, SD = 392.9). However, no significant differences were found when comparing the number of procedures performed by region ($p = 0.472$) (Table 3).

4. Discussion

While postoperative rehabilitation programs have proven to be a valuable component to the recovery process, there is no clear-cut

Table 1

Surgeon-reported preferences and trust in post-arthroscopic rehabilitation, stratified by joint-specific and overall arthroscopy.

Post-Arthroscopic Rehabilitation Beliefs	Shoulder	Elbow	Wrist	Hip	Knee	Ankle	Total	P-value
Physical Therapy (<i>n</i>)	96.21% (290)	88.78% (98)	71.88% (32)	98.39% (62)	88.47% (295)	91.3% (92)	91.5% (869)	< 0.0001
Home Exercise Programs (<i>n</i>)	94.1% (288)	93.75% (96)	96.55% (29)	91.94% (62)	95.53% (291)	88.04% (92)	94.4% (858)	0.182
P-value (PT vs. HEP)	0.238	0.221	0.009	0.094	0.002	0.467	0.063	

The values in bold indicate statistical significance ($p < 0.05$).

Table 2

Survey results for modalities employed to conveying home-exercise program (HEP) instructions to patients.

Mechanism	Shoulder	Elbow	Wrist	Hip	Knee	Ankle	Total	P-value
Web	8	3	1	3	7	2	24 (2.9%)	0.058
Verbal	76	42	14	16	87	31	266 (31.9%)	
Handouts	185	47	14	34	185	47	512 (61.4%)	
Unsure	14	1	1	5	7	4	32 (3.8%)	
Total	283	93	30	58	286	84	834	

Table 3

Epidemiological results describing the arthroscopic surgeries performed annually. Results were stratified by geographic region, and survey results were utilized to predict the overall number of annual arthroscopies performed.

Geographic Location	# of Survey Respondents	Reported # Arthroscopic Surgeries Annually	Mean # Arthroscopic Surgeries $\pm$ SD	Predicted Total # Annual Arthroscopies	P-value
United States					0.472
<i>Northeast</i>	49	13,222	269.8 $\pm$ 157.1	205,334	
<i>South</i>	102	36,140	354.3 $\pm$ 392.9	805,404	
<i>Midwest</i>	44	13,592	308.9 $\pm$ 187.6	302,690	
<i>West</i>	49	16,441	335.5 $\pm$ 347.8	366,414	
Total U.S.	244	79,395	325.4 $\pm$ 316.5	1,770,118	
Other U.S. Territories	1	275	–	–	–
Foreign (outside U.S.)	78	15,692	–	–	–
Overall Total	323	95,362	–	–	–

agreement in the literature as to their requirement for full recovery for patients. By employing a distributable survey, this investigation determined that there is strong support amongst AANA members for the utilization of post-arthroscopic rehabilitative physical therapy and HEPs. In comparing SPT to HEPs among various joint surgeons, a significant difference was found between surgeons with respect to their belief in the use of physical therapy; however, no such difference was found with respect to HEPs. Additionally, this study provided an estimate of the annual number of arthroscopic surgeries performed within the US as well as a regional distribution. An estimated 1.77 million surgeries were performed in a 12-month period, with the majority occurring in the South (805,404). While it still remains unclear if there is an added benefit to SPT compared to HEPs, this study revealed a clear consensus that it is the popular opinion of practicing arthroscopists for the use of some form of post-surgical rehabilitation.

Multiple works corroborate the findings of this study pertaining to the added benefit of post-surgical rehabilitation for the greatest degree of functional recovery and patient satisfaction.^{9–12} Specifically, Ericsson et al.¹³ compared physical outcomes of patients following meniscectomy, as measured by hamstring strength and quadriceps endurance, between those who underwent physical therapy and those (controls) who received no intervention, and a significant increase in functional performance was found in the treatment group. The argument still remains whether or not there is an added benefit to SPT programs compared to HEPs. The present study found that physicians believe that both physical therapy and HEPs have value; however, it is currently not possible to report on the superiority of one over the other. A recent randomized control trial and systematic review both report a lack of significant difference between the two modalities.^{14,15} Two studies have attempted to determine a difference between SPT and HEPs by using the Lysholm scale, a patient-reported questionnaire designed to reflect loss of function and complaints during activities of daily living, as a measure of benefit; one favored SPT,⁶ whereas the other failed to show a difference.³ The apparent discord in the literature with some studies favoring SPT may be attributed to the demographics of study participants. Younger and healthier patients may show an increase in functional rehabilitation following any modality of therapy, and as such studies comparing the elderly and individuals with various comorbidities should be conducted before a definite answer can be given. Moreover, the complexity of the surgery and the degree of

intraoperative complications may have an impact on the postoperative recovery period, and may influence whether patients would benefit from SPT.

Although this study reiterated the popular notion that both SPT and HEPs are of value, other studies have found superiority in one modality over the other. Grant et al.¹⁶ found that HEP patients who underwent ACL reconstruction had greater flexion and extension range of motion (ROM) compared to the physical therapy group, with significantly higher ACL quality of life scores at 2–4 year follow-up.^{15,16} Yet, Vervest et al.⁶ and Moffet et al.³ found that patients undergoing SPT had superior outcomes related to functional outcomes scores and knee extensor strength, respectively, when compared to HEP; however, Moffet et al.³ did not show significant differences in ROM. The inconsistency with respect to the value of SPT may be accounted for by the variance in rehabilitative regimens between practitioners, which may also vary based on the involved joint. Further investigation into how post-surgical rehabilitative outcomes following procedures for different joints vary, as well as whether different forms of physical therapy are superior to one another, is warranted.

This study evaluated the method by which HEPs were recommended to patients; consistent with previous studies,¹⁷ the survey revealed that the majority were in the form of handouts from surgeons' offices, followed by verbal instructions. Despite reports of improved patient outcomes associated with proper adherence to HEPs,^{18,19} upward of 70% of patients fail to comply with HEP instructions, with declining compliance over time.¹⁹ Many factors have been proposed to influence adherence, including treatment costs, poor patient-provider relations, lack of trust in the therapist, difficulty in making time for therapy, and a desire to return to baseline with unrealistic expectations of recovery timeline and efforts.²⁰ Time required for travel, time taken until recovery, wait-time in a therapist's office all contribute to non-adherence to rehabilitative measures. Costs related to rehabilitative care limit participation as well. Insurance companies may limit the number of covered visits or set high copays. Each year \$29.6 billion is spent on outpatient rehabilitation therapy,²¹ and \$24 billion per year accounts for expenditures secondary to physical inactivity.²²

Surprisingly, this survey revealed that only 2.9% of patients were referred to web-based rehabilitation resources. Given society's heavy dependence on internet-based technology, it was unexpected to find such a low proportion of physicians utilizing web-based protocols to

implement HEPs. There is a paucity of studies that have focused on the success of web-based rehabilitation modalities. Coulter et al.²³ documented success in providing web-based physiotherapy for people with spinal cord injuries, while Brooks et al.²⁴ showed how the use of an 8-week web-based physiotherapy program for osteoarthritis patients led to higher reported World Health Organization Quality of Life Scores, as well as better functionality and less pain. The lack of reported evidence indicates an area of potential growth related to arthroscopic surgery and web-based resources to help achieve better patient outcomes. Web-based HEPs offer the potential for a cost-effective, convenient, and personalized rehabilitation regimen with higher patient satisfaction. Moreover, a reliable web-based HEP can help bridge the communication gap between surgeons, patients, and rehabilitative specialists.

With outpatient therapy services accounting for upwards of 40% of the total cost of surgery and nearly \$180.4 million for U.S. Medicare patients,^{25, 26} there is potential for great value in web-based HEPs. Though previous comparisons of delivery methods for HEPs have failed to show added benefits of videos or audiotapes over paper handouts,^{27–29} web-based implementation of HEPs offer the potential for significant cost-saving. No previous studies have examined the cost-effectiveness of using web-based protocols for postoperative HEPs; yet, a randomized control trial protocol to evaluate the cost-effectiveness of partial substitution of web-based intervention for exercise therapy sessions in patients with osteoarthritis has recently been published.³⁰ Cost-effectiveness studies of web-based interventions have previously focused on mental health and behavioral medicine, with promising cost-saving results.³¹ The authors of the present study speculate that the ability to monitor patient-logged progress in real-time is crucial to the success of web-based HEPs, and reliable web-based HEPs may lead to improved long-term patient outcomes following surgical arthroscopy. A patient recording progress as a form of self-monitoring has been shown to increase adherence³² and professional monitoring, especially with interactive features, may encourage adherence.^{33, 34} Studies evaluating telerehabilitation have demonstrated its safety and reported comparable outcomes to conventional in-person physical therapy.^{23, 35}

Several web-based HEPs exist,³⁶ offering instructional videos, progress monitoring for providers and patients, and personal physiotherapist videoconferencing. Extension of PT into the patient's home offers a desirable level of convenience, and allows for greater and more consistent collaboration between the patient and physical therapist. In order to optimize their utility, HEPs can be suggested by physical therapists as 'homework' during the period of SPT. Providers can benefit from HEP monitoring capabilities and customization in order to design patient-specific exercise bundles. As such, further study of the outcomes, impact on patient satisfaction, and preventative value of such programs is warranted.

4.1. Limitations

This study was not without limitations, most of which were due to the survey format. Inherent to surveys are the potential to introduce bias and skew the results. Data errors exist due to questions without responses, which may distort the final survey results. Additionally, the free-text feature of this survey allowed for respondents to provide responses in variable ways, introducing the potential for error in analysis. Likewise, the use of respondent IP addresses to determine geographical region within the United States limits survey accuracy, as respondents may have answered the survey away from their home practice. Given that only a portion of survey participants responded, the calculations may overestimate the incidence of arthroscopic procedures completed annually. Contributing to a potential overestimation is the fact that members of medical societies, such as the AANA, include retirees and residents, among others, who may have chosen to omit the portion of the survey that were used to predict incidence; however, in calculation we accounted for them. However, the questions that were selected for this survey are believed to be unbiased and solely reflect on popular

opinion with regards to postoperative rehabilitation programs; the data obtained and analyzed can be parlayed into a valid representation of contemporary professional practices. This represents the first study of its kind, to our knowledge, to sample from such a wide range of practicing arthroscopists.

5. Conclusions

This study was able to conclude that there is significant agreement among the surgical community in favor of post-surgical rehabilitation. While the results confirmed agreement among AANA members with regards to the use of HEPs, significant differences existed in regards to the use of SPT following certain arthroscopic procedures. Moreover, it demonstrated an area of potential growth with respect to the underutilization of web-based HEPs, despite the cost-saving potential it may offer. This study was also able to quantify the number of arthroscopic procedures performed annually within the United States, and separate them geographically. This is the first known study to estimate the annual procedural volume for joint arthroscopies, offering insight into the probability of occurrence of a joint arthroscopy among Americans. Evaluation into the prevalence of this procedure and further analysis of arthroscopic trends may support the need to institute more cost-effective post-surgical rehabilitation models. Future investigation should compare SPT and HEPs in the elderly and individuals with various comorbidities and focus on the utility and cost-effectiveness of web-based HEPs.

Conflicts of interest

There were no direct or indirect conflicts of interests or disclosures that were related to any aspect of this work. The authors have the following disclosures to report:

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References

- Jokl P, Stull PA, Lynch JK, Vaughan V. Independent home versus supervised rehabilitation following arthroscopic knee surgery-a prospective randomized trial. *Arthroscopy*. 1989;5(4):298–305. [http://dx.doi.org/10.1016/0749-8063\(89\)90145-x](http://dx.doi.org/10.1016/0749-8063(89)90145-x).
- Gill TJ, Moezzi DM, Oates KM, Sterett WI. Arthroscopic reduction and internal fixation of tibial plateau fractures in skiing. *Clin Orthop Relat Res*. 2001;383:243–249.
- Moffet H, Richards CL, Malouin F, Bravo G, Paradis G. Early and intensive physiotherapy accelerates recovery postarthroscopic meniscectomy: results of a randomized controlled study. *Arch Phys Med Rehabil*. 1994;75(4):415–426.
- van der Meijden OA, Westgard P, Chandler Z, Gaskill TR, Kokmeyer D, Millett PJ. Rehabilitation after arthroscopic rotator cuff repair: current concepts review and evidence-based guidelines. *Int J Sports Phys Ther*. 2012;7(2):197–218.
- Austin MS, Urbani BT, Fleischman AN, et al. Formal physical therapy after total hip arthroplasty is not required: a randomized controlled trial. *J Bone Jt Surg Am*. 2017;99(8):648–655. <http://dx.doi.org/10.2106/JBJS.16.00674>.
- Vervest AM, Maurer CA, Schamberg TG, de Bie RA, Bulstra SK. Effectiveness of physiotherapy after meniscectomy. *Knee Surg Sports Traumatol Arthrosc*. 1999;7(6):360–364. <http://dx.doi.org/10.1007/s001670050181>.
- Holmgren T, Öberg B, Sjöberg I, Johansson K. Supervised strengthening exercises versus home-based movement exercises after arthroscopic acromioplasty: a randomized clinical trial. *J Rehabil Med*. 2012;44(1):12–18. <http://dx.doi.org/10.2340/16501977-0889>.
- Census regions and divisions of the United States. 2015; 2015. (Accessed 25 June 2017). https://www2.census.gov/geo/pdfs/maps-data/maps/reference/us_regdiv.pdf.

9. Bennell KL, Spiers L, Takla A, et al. Efficacy of adding a physiotherapy rehabilitation programme to arthroscopic management of femoroacetabular impingement syndrome: a randomised controlled trial (FAIR). *BMJ Open*. 2017;7(6):e014658. <http://dx.doi.org/10.1136/bmjopen-2016-014658>.
10. Cavanaugh JT, Killian SE. Rehabilitation following meniscal repair. *Curr Rev Musculoskelet Med*. 2012;5(1):46–58. <http://dx.doi.org/10.1007/s12178-011-9110-y>.
11. Papalia R, Vasta S, Tecame A, D'Adamio S, Maffulli N, Denaro V. Home-based vs supervised rehabilitation programs following knee surgery: a systematic review. *Br Med Bull*. 2013;108:55–72. <http://dx.doi.org/10.1093/bmb/ldt014>.
12. Kelln BM, Ingersoll CD, Saliba S, Miller MD, Hertel J. Effect of early active range of motion rehabilitation on outcome measures after partial meniscectomy. *Knee Surg Sports Traumatol Arthrosc*. 2009;17(6):607–616. <http://dx.doi.org/10.1007/s00167-009-0723-2>.
13. Ericsson YB, Dahlberg LE, Roos EM. Effects of functional exercise training on performance and muscle strength after meniscectomy: a randomized trial. *Scand J Med Sci Sports*. 2009;19(2):156–165. <http://dx.doi.org/10.1111/j.1600-0838.2008.00794.x>.
14. Goodwin PC, Morrissey MC, Omar RZ, Brown M, Southall K, McAuliffe TB. Effectiveness of supervised physical therapy in the early period after arthroscopic partial meniscectomy. *Phys Ther*. 2003;83(6):520–535.
15. Coppola SM, Collins SM. Is physical therapy more beneficial than unsupervised home exercise in treatment of post surgical knee disorders? A systematic review. *Knee*. 2009;16(3):171–175. <http://dx.doi.org/10.1016/j.knee.2008.09.001>.
16. Grant JA, Mohtadi NGH, Maitland ME, Zernicke RF. Comparison of home versus physical therapy-supervised rehabilitation programs after anterior cruciate ligament reconstruction: a randomized clinical trial. *Am J Sports Med*. 2005;33(9):1288–1297. <http://dx.doi.org/10.1177/0363546504273051>.
17. Schneiders A, Zusman M, Singer K. Exercise therapy compliance in acute low back pain patients. *Man Ther*. 1998;3(3):147–152. [http://dx.doi.org/10.1016/S1356-689X\(98\)80005-2](http://dx.doi.org/10.1016/S1356-689X(98)80005-2).
18. Pisters MF, Veenhof C, de Bakker DH, Schellevis FG, Dekker J. Behavioural graded activity results in better exercise adherence and more physical activity than usual care in people with osteoarthritis: a cluster-randomised trial. *J Physiother*. 2010;56(1):41–47. [http://dx.doi.org/10.1016/S1836-9553\(10\)70053-9](http://dx.doi.org/10.1016/S1836-9553(10)70053-9).
19. Beinart NA, Goodchild CE, Weinman JA, Ayis S, Godfrey EL. Individual and intervention-related factors associated with adherence to home exercise in chronic low back pain: a systematic review. *Spine J*. 2013;23(12):1940–1950. <http://dx.doi.org/10.1016/j.spinee.2013.08.027>.
20. Smith-Forbes EV, Howell DM, Willoughby J, Armstrong H, Pitts DG, Uhl TL. Adherence of individuals in upper extremity rehabilitation: a qualitative study. *Arch Phys Med Rehabil*. 2016;97(8):1262–1268.e1. <http://dx.doi.org/10.1016/j.apmr.2015.11.008>.
21. Physical therapy market overview. 2014; 2014 http://www.harriswilliams.com/system/files/industry_update/2014.2.17_physical_therapy_overview.pdf.
22. University FA, Sobering Statistics on Physical Inactivity in the U.S. ScienceDaily. www.sciencedaily.com/releases/2015/08/150826093015.htm. Published 2015. (Accessed 1 January 2017).
23. Coulter EH, McLean AN, Hasler JP, Allan DB, McFadyen A, Paul L. The effectiveness and satisfaction of web-based physiotherapy in people with spinal cord injury: a pilot randomised controlled trial. *Spinal Cord*. 2017;55(4):383–389. <http://dx.doi.org/10.1038/sc.2016.125>.
24. Brooks MA, Beaulieu JE, Severson HH, et al. Web-based therapeutic exercise resource center as a treatment for knee osteoarthritis: a prospective cohort pilot study. *BMC Musculoskelet Disord*. 2014;15(158) <http://dx.doi.org/10.1186/1471-2474-15-158>.
25. Ong KL, Lotke PA, Lau E, Manley MT, Kurtz SM. Prevalence and costs of rehabilitation and physical therapy after primary TJA. *J Arthroplasty*. 2015;30(7):1121–1126. <http://dx.doi.org/10.1016/j.arth.2015.02.030>.
26. Minns Lowe CJ, Barker KL, Dewey ME, Sackley CM. Effectiveness of physiotherapy exercise following hip arthroplasty for osteoarthritis: a systematic review of clinical trials. *BMC Musculoskelet Disord*. 2009;10(98) <http://dx.doi.org/10.1186/1471-2474-10-98>.
27. Lysack C, Dama M, Neufeld S, Andreassi E. A compliance and satisfaction with home exercise: a comparison of computer-assisted video instruction and routine rehabilitation practice. *J Allied Health*. 2005;34(2):76–82.
28. Sacomori C, Berghmans B, Mesters I, de Bie R, Cardoso FL. Strategies to enhance self-efficacy and adherence to home-based pelvic floor muscle exercises did not improve adherence in women with urinary incontinence: a randomised trial. *J Physiother*. 2015;61(4):190–198. <http://dx.doi.org/10.1016/j.jphys.2015.08.005>.
29. Schoo A, Morris M, Bui Q. The effects of mode of exercise instruction on compliance with a home exercise program in older adults with osteoarthritis. *Physiotherapy*. 2005;91(2):79–86. <http://dx.doi.org/10.1016/j.physio.2004.09.019>.
30. Kloek CJJ, Bossen D, Veenhof C, van Dongen JM, Dekker J, de Bakker DH. Effectiveness and cost-effectiveness of a blended exercise intervention for patients with hip and/or knee osteoarthritis: study protocol of a randomized controlled trial. *BMC Musculoskelet Disord*. 2014;15(269) <http://dx.doi.org/10.1186/1471-2474-15-269>.
31. Tate DF, Finkelstein EA, Khavjou O, Gustafson A. Cost effectiveness of internet interventions: review and recommendations. *Ann Behav Med*. 2009;38(1):40–45. <http://dx.doi.org/10.1007/s12160-009-9131-6>.
32. Jordan JL, Holden MA, Mason EE, Foster NE. Interventions to improve adherence to exercise for chronic musculoskeletal pain in adults. *Cochrane Database Syst Rev*. 2010(1):CD005956. <http://dx.doi.org/10.1002/14651858.CD005956.pub2>.
33. Chow C, Redfern J, Hillis G, Thakkar J, Santo K, Hackett M. Effect of lifestyle-focused text messaging on risk factor modification in patients with coronary heart disease: a randomized clinical trial. *JAMA*. 2015;314:1255–1263.
34. Bennell KL, Campbell PK, Egerton T, et al. Telephone coaching to enhance a home-based physical activity program for knee osteoarthritis: a randomized clinical trial. *Arthritis Care Res (Hoboken)*. 2017;69(1):84–94. <http://dx.doi.org/10.1002/acr.22915>.
35. Shukla H, Nair SR, Thakker D. Role of telerehabilitation in patients following total knee arthroplasty: evidence from a systematic literature review and meta-analysis. *J Telemed Telecare*. 2017;23(2):339–346. <http://dx.doi.org/10.1177/1357633X16628996>.
36. Kim TWB, Gay N, Khemka A, Garino J. Internet-based exercise therapy using algorithms for conservative treatment of anterior knee pain: a pragmatic randomized controlled trial. *JMIR Rehabil Assist Technol*. 2016;3(2):e12. <http://dx.doi.org/10.2196/rehab.5148>.