Original Article

Reducing the Use of Complex Words and Reducing Sentence Length to <15 Words Improves Readability of Patient Education Materials Regarding Sports Medicine Knee Injuries

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Purpose: To develop a standardized method to improve readability of orthopaedic patient education materials (PEMs) without diluting their critical content by reducing the use of complex words ($\geq$3 syllables) and shortening sentence length to $\leq$15 words. **Methods:** OrthoInfo, a patient education website developed by the Academy of American Orthopedic Surgeons, was queried for PEMs relevant to the care of athletic injuries of the knee. Inclusion criteria were PEMs that were unique, pertained to topics of knee pathology in sports medicine, and written in a prose format. Exclusion criteria were information presented in video or slideshow format, or topics not pertaining to knee pathology in sports medicine. Readability of PEMs was evaluated using 7 unique readability formulas before and after applying a standardized method to improve readability while preserving critical content (reducing the use of $\geq$3 syllable words and ensuring sentence length is $\leq$15 words). Paired samples *t*-tests were conducted to assess the relationship between reading levels of the original PEMs and reading level of edited PEMs. **Results:** Reading levels differed significantly between the 22 original PEMs and edited PEMs across all 7 readability formulas ($P < .01$). Mean Flesch Kincaid Grade Level of original PEMs (9.8 ± 1.4) was significantly increased compared to that of edited PEMs (6.4 ± 1.1) ($P = 1.9 \times 10^{-13}$). 4.0% of original PEMs met National Institutes of Health recommendations of a sixth-grade reading level compared with 48.0% of modified PEMs. **Conclusions:** A standardized method that reduces the use of $\geq$3 syllable words and ensures sentence length is $\leq$15 words significantly reduces the reading-grade level of PEMs for sports-related knee injuries. Orthopaedic organizations and institutions should apply this simple standardized method when creating PEMs to enhance health literacy. **Clinical Relevance:** The readability of PEMs is important when communicating technical material to patients. While many studies have suggested strategies to improve the readability of PEMs, literature describing the benefit of these proposed changes is scarce. The information from this study details a simple standardized method to use when creating PEMs that may enhance health literacy and improve patient outcomes.

The internet has become a vast resource for medical information. Approximately one-half of adult internet users have reported using the internet to learn more information about a specific medical treatment or procedure.[1] In response to this current trend, the American Academy of Orthopaedic Surgeons (AAOS) has developed online patient education materials (PEMs) to enhance patient–doctor communication and improve patient health literacy in the treatment of orthopaedic conditions.[2,3] However, although the internet can be a vast source of information, its usefulness in patient care is dependent not only on the content available to patients but also the health literacy of the patient consuming the information.

Health literacy is the capacity to obtain, process, and understand basic health concepts needed to make

appropriate health decisions.[3-5] Health literacy is considered to be the single best predictor of a patient's health status, with poor health literacy leading to worse patient outcomes.[3,6,7] Poor health literacy has been associated with more frequent hospital admissions, longer hospital stays, increased risk for seeking emergency care, increased complications, reduced compliance, and more frequent missed appointments.[3,6,8-13] Not only does poor health literacy bring worse outcomes for the patient, but it also contributes an estimated $73 billion of additional cost burden to the U.S. health care system.[3] To be effective, PEMs must be written at a level that the target population can comprehend.

There is clearly a disparity with regards to health literacy in the United States. It is estimated that approximately 21% of U.S. adults read at, or below a fifth-grade reading level, described as "functionally illiterate."[1,3,14] An additional 30% of U.S. adults read between a sixth-grade and eighth-grade reading level, termed "marginally literate." [1,3,14] Furthermore, nearly one-half of the Hispanic and African American US population is functionally illiterate.[3,15,16] Therefore, the American Medical Association and National Institutes of Health recommend that all PEMs be written at or below a sixth-grade reading level.[1-4,17,18]

Sports-related knee injuries such as anterior cruciate ligament or meniscus tears are very common, and there are ample resources for knee injury-related PEMs. However, anatomy, pathology, and treatment plans of knee injuries often are described in terms that are obscure to patients. Complex, multisyllable terminology, including "anterior cruciate ligament," "articular cartilage," "meniscectomy," or "arthroscopy," can be foreign and confusing terms for patients. Therefore, the field of sports medicine, specifically involving knee pathology, is rife with the possibility for misunderstanding, leading to low patient health literacy. Improving the readability of orthopaedic PEMs is a realistic and important goal to improve the health literacy and overall health of patients. While many studies have suggested simple strategies to improve readability scores of PEMs such as reducing complex words, literature describing the benefit of these proposed changes is scarce.[2,17] The purpose of this study is to develop a standardized method that can be applied to orthopaedic knee injury—related PEMs for the purpose of improving their readability without diluting their critical content. We hypothesized that reducing the use of complex words (≥3 syllables) and shortening sentence length to ≤15 words would improve the readability of orthopaedic PEMs.

Methods

Data Collection
OrthoInfo, a patient education website developed and reviewed by the AAOS, was queried for PEMs relevant to the care of athletic injuries of the knee.[19] All PEMs were collected by a single author from OrthoInfo (S.H.). Inclusion criteria were PEMs that were unique articles, pertained to topics of knee pathology in sports medicine, and written in a prose format. Exclusion criteria were information presented in video or slideshow format or topics not pertaining to knee pathology in sports medicine. A total of 205 PEMs were available for review for the study. After application of inclusion and exclusion criteria, 22 PEMs were included in the study (Table 1).

Determination of Readability
The reading level of each PEM was calculated using an online tool.[20] Reading level was evaluated by 7 readability formulas, including Flesch Reading Ease score, Gunning-Fog, Flesch—Kincaid Grade Level, The Coleman—Liau Index, The Simple Measure of Gobbledygook Index, Automated Readability Index, and Linsear Write Formula (Table 2). Additional data recorded for each PEM included total number of words, mean number of words per sentence, mean number of syllables per word, and percentage of complex words.

Assessing Readability
Each PEM was accessed on and downloaded from OrthoInfo.com. The content of each PEM was copy and pasted into a new Microsoft Word document. This content was then copy and pasted into the text box of the Automatic Readability Checker on www.readabilityformulas.com/. The option to "Check Text Readability" was selected and the readability data for each PEM was recorded.

Applying the Standardized Method to Improve Readability
After evaluating the readability of the original PEMs provided by OrthoInfo, the original documents were edited using a standardized method for improvement of readability while preserving critical content of the PEM (S.H., N.C., S.G., J.B.). The standardized method involved reducing the use of complex words (≥3 syllables) and ensuring sentence length was ≤15 words. The application of these editing techniques reflects the most often cited techniques for improving readability, which include replacing complex medical jargon with simpler terms and shortening sentence length to 10-15 words per sentnces.[2,3,8,17,18,21,22] Critical content was described as medical information necessary for patient understanding of the described knee pathology and determined by the author who originally collected the PEMs (S.H.). Individuals determining critical content are preferably practicing orthopaedic surgeons; however, critical content also can be determined by individuals training within the field of orthopaedic surgery. Investigators were limited to a single round of

Table 1. Readability Formula Scores of Seven Independent Readability Formulas for Original Versus Edited PEMs Included in the Present Study

PEM: Article Title	Flesch Reading Ease Score		Gunning Fog		Flesch–Kincaid Grade Level		The Coleman-Liau Index		The SMOG Index		Automated Readability Index		Linsear Write Formula	
	Original	Edited	Original	Edited	Original	Edited	Original	Edited	Original	Edited	Original	Edited	Original	Edited
Adolescent Anterior Knee Pain	48.8	63.5	13.5	9.2	11.2	7.5	12.0	11.0	10.3	7.4	11.8	7.5	12.7	6.8
Anterior Cruciate Ligament (ACL) Injuries	49.4	65.6	12.9	8.5	10.0	6.6	12.0	11.0	10.1	7.1	9.9	6.3	9.4	5.5
Collateral Ligament Injuries	61.3	75.6	11.4	7.5	8.1	4.9	10.0	9.0	8.8	6.0	7.8	4.5	8.2	4.4
Combined Knee Ligament Injuries	52.5	69.7	13.3	8.3	9.5	5.6	11.0	10.0	10.0	6.5	9.0	5.0	9.0	4.4
Common Knee Injuries	52.9	69.7	11.6	8.3	9.6	5.6	12.0	10.0	9.8	6.5	9.4	5.0	9.2	4.4
Meniscus Tears	55.3	69.9	11.7	7.7	8.7	5.7	11.0	10.0	8.9	6.3	8.4	5.3	7.7	4.5
Osgood–Schlatter Disease (Knee Pain)	55.5	73.2	12.6	8.2	9.7	6.0	12.0	10.0	9.2	6.2	10.8	6.7	11.0	6.1
Patellar Dislocation and Instability in Children (Unstable Kneecap)	52.5	68.6	13.0	9.2	10.1	6.6	12.0	10.0	9.9	7.3	10.3	6.3	11.2	6.3
Patellar Tendon Tear	56.5	70.7	11.6	8.7	9.1	6.3	11.0	9.0	8.8	6.7	9.1	6.2	8.7	6.2
Patellofemoral Pain Syndrome	51.9	70.7	12.9	8.6	10.4	6.3	12.0	9.0	9.8	6.7	10.8	6.3	11.6	6.1
Pes Anserine (Knee Tendon) Bursitis	42.9	63.0	14.4	10.0	11.6	7.6	13.0	10.0	11.1	7.9	11.6	7.5	12.4	7.2
Posterior Cruciate Ligament (PCL) Injuries	46.2	66.4	15.1	10.2	10.9	6.7	12.0	9.0	11.1	7.6	10.4	5.6	12.0	6.1
Shin Splints	57.5	63.1	11.5	9.8	8.4	7.0	12.0	11.0	8.4	7.3	8.6	7.0	7.4	5.7
Unstable Kneecap	64.4	73.9	11.4	8.3	8.6	5.9	9.0	9.0	8.3	6.3	9.2	5.9	10.8	6.1
ACL Injury: Does It Require Surgery?	37.7	53.0	16.9	12.5	13.3	9.6	13.0	12.0	12.4	9.4	13.8	9.5	15.4	9.0
Knee Arthroscopy Exercise Guide	71.1	77.7	8.0	6.3	6.0	4.7	10.0	9.0	6.3	5.2	5.9	4.4	5.5	4.4
Knee Arthroscopy	49.8	60.4	13.4	10.7	10.4	8.1	12.0	11.0	10.2	8.3	10.8	8.1	11.4	7.6
Meniscal Transplant Surgery	49.8	69.8	13.2	8.1	10.2	6.7	12.0	10.0	10.0	6.4	10.1	6.9	10.7	6.5
Discoid Meniscus	53.9	67.9	12.4	8.5	9.4	6.5	12.0	10.0	9.4	6.6	9.5	6.4	9.0	5.7
Arthritis of the Knee	48.6	73.3	13.7	7.5	10.6	5.7	13.0	10.0	10.3	6.0	11.1	5.8	11.4	5.3
Osteonecrosis of the Knee	49.9	72.8	12.5	6.7	10.4	6.0	12.0	9.0	9.7	5.4	10.4	6.0	11.0	5.6
Patellofemoral Arthritis	55.6	75.6	11.4	6.5	8.8	5.3	12.0	10.0	8.8	5.4	9.2	5.8	8.0	5.0
Mean values	52.9	68.8	12.7	8.6	9.8	6.4	11.7	10.0	9.6	6.8	9.9	6.3	10.2	5.9
Standard deviation	6.9	5.6	1.7	1.4	1.4	1.1	1.0	0.8	1.2	1.0	1.6	1.2	2.1	1.1

PEMs, patient education materials; SMOG, Simple Measure of Gobbledygook.

Table 2. Descriptions of the Seven Independent Readability Formulas Used to Evaluate Handouts in the Current Study

Readability Assessment	Formula	Description
Flesch−Kincaid grade level	$(0.39 \times B) + (11.8 \times W) - 15.59$	B = mean number of syllables per word W = mean number of words per sentence
Flesch Reading Ease	$206.835 - (1.015 \times W) - (84.6 \times B)$	B = mean number of syllables per word W = mean number of words per sentence
Simple Measure of Gobbledygook (SMOG) Index	$1.043 \times \sqrt{(P \times 30)} + 3.1291$	P = number of words with ≥3 syllables S = number of sentences
Coleman−Liau	$(0.0588 \times L) - (0.296 \times T) - 15.8$	L = mean number of letters/word T = mean number of sentences/100 words
Gunning Fog	$0.4 \times (W/S + 100 - P/W)$	S = mean number of sentences W = mean number of words/sentence P = mean number of words with ≥3 syllables
Automated Readability Index	$4.71 \text{ (characters/words)} + 0.5 \text{ (words/sentences)} - 21.43$	
Linsear Write	No formula—calculates the U.S. grade level of a text sample based on sentence length and the number of words with 3 or more syllables.	

editing in further attempts to preserve critical content. After editing, the reading level of each PEM was evaluated for a second time using the aforementioned criteria. The same readability formulas and same additional datapoints were recorded for the edited documents as for the original documents.

Statistical Analysis

Mean reading level, percentage of PEMs above a sixth-grade reading level, and percentage of PEMs at-or-below sixth-grade reading level were calculated for both original and edited PEMs. In addition, the mean change in reading level after editing was calculated for original and edited PEMs. Extracted data were analyzed through SPSS software version 19.0. Categorical variables are reported in frequencies and percentages. In addition, statistical analysis was conducted using paired-sample t-test to determine differences in reading level between original PEMs and edited PEMs. Paired samples t-tests were conducted to assess the relationship between reading levels of the original PEMs and reading level of edited PEMs. A P-value of .05 was deemed statistically significant.

Results

A total of 205 PEMs were available for review. Of these, 22 met the inclusion criteria and were included in the study (Fig 1). Reading levels differed significantly between the 22 original PEMs and edited PEMs across all 7 readability formulas ($P < .01$) (Table 1). Using the Flesch−Kincaid Grade Level readability formula, we found that the mean reading level for original PEMs was 9.77 ± 1.42 compared before modification with 6.40 ± 1.08 for edited PEMS ($P = 1.9 \times 10^{-13}$). Per the Flesch−Kincaid Grade level readability formula, one

original PEM (4.0%) versus 12 edited PEMs (48.0%) met National Institutes of Health recommendations of a sixth-grade reading level before and after changes respectively. Readability formula scores and numerical data for each PEM evaluated is displayed in Tables 1 and 3. Readability scores across these 7 readability formulas are summarized in Table 4.

The relationship between additional numerical data describing the original PEMs and edited PEMs, including mean number of words, mean words per sentence, mean characters per word, mean syllables per word, mean percentage of complex words, and mean number of complex words differed significantly. The mean number of words per sentence was measured to
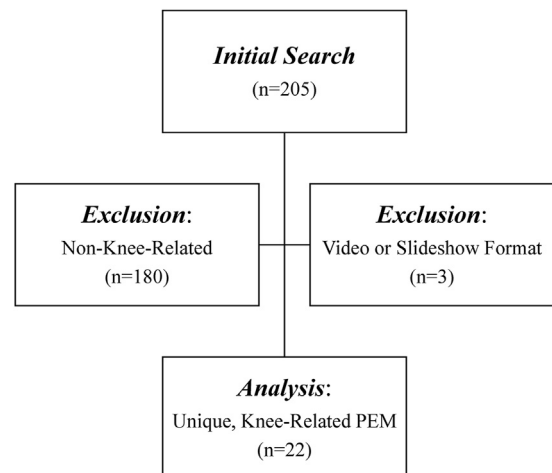
Fig 1. Application of inclusion and exclusion criteria to patient education materials (PEMs) collected from a query of OrthoInfo.com for PEMs relevant to the care of athletic injuries of the knee.

Table 3. Numerical Descriptive Statistics for Original Versus Edited PEMs Included in the Present Study

Patient Education Material: Article Title	Number of Words (Total)		Words per Sentence		Mean Characters per Word		Mean Syllables per Word		% of 3+ Syllable Words		No. of 3+ Syllable Words	
	Original	Edited	Original	Edited	Original	Edited	Original	Edited	Original	Edited	Original	Edited
Adolescent Anterior Knee Pain	1,469	1,408	19	12	5	4.8	2	2	17%	13%	244	176
Anterior Cruciate Ligament (ACL) Injuries	1,333	1,247	15	10	5.1	4.8	2	2	21%	14%	277	178
Collateral Ligament Injuries	1,048	926	14	9	4.7	4.6	2	1	16%	11%	172	106
Combined Knee Ligament Injuries	752	641	14	8	4.9	4.7	2	2	21%	14%	156	91
Common Knee Injuries	1,316	641	15	8	5	4.7	2	2	19%	14%	252	91
Meniscus Tears	1,239	1,099	13	9	5	4.7	2	2	18%	12%	226	137
Osgood-Schlatter Disease (Knee Pain)	626	590	17	12	5	4.7	2	1	15%	9%	93	52
Patellar Dislocation and Instability in Children (Unstable Kneecap)	996	1,032	17	12	5	4.7	2	1	18%	13%	175	135
Patellar Tendon Tear	1,890	1,819	15	12	4.9	4.6	2	1	15%	11%	287	199
Patellofemoral Pain Syndrome	1,844	1,769	18	12	5	4.6	2	1	16%	11%	298	191
Pes Anserine (Knee Tendon) Bursitis	439	446	18	13	5.2	4.8	2	2	21%	14%	91	63
Posterior Cruciate Ligament (PCL) Injuries	1,195	1,131	17	11	5	4.6	2	2	22%	15%	263	172
Shin Splints	1,165	1,040	13	10	5	4.9	2	2	16%	15%	191	153
Unstable Kneecap	473	457	18	12	4.6	4.5	1	1	11%	9%	54	42
ACL Injury: Does It Require Surgery?	3,143	3,145	22	15	5.2	5	2	2	22%	17%	678	548
Knee Arthroscopy Exercise Guide	1,106	1,074	11	9	4.7	4.5	1	1	10%	8%	114	83
Knee Arthroscopy	1,708	1,402	17	13	5.1	4.9	2	2	19%	15%	317	214
Meniscal Transplant Surgery	1,175	1,037	15	13	5.1	4.7	2	1	19%	9%	226	92
Discoid Meniscus	1,266	1,165	15	11	5	4.7	2	2	17%	11%	221	132
Arthritis of the Knee	2,340	1,920	16	11	5.2	4.8	2	1	19%	9%	451	176
Osteonecrosis of the Knee	1,774	1,543	16	12	5	4.6	2	1	17%	7%	300	104
Patellofemoral Arthritis	1,440	1,208	13	11	5.1	4.7	2	1	17%	7%	242	90
Mean values	1,351.7	1,215.5	15.8	11.1	5.0	4.7	1.9	1.5	17.5%	11.7%	242.2	146.6
Standard deviation	600.3	584.4	2.4	1.7	0.2	0.1	0.3	0.5	3%	3%	129.1	100.2

PEMs, patient education materials.

Table 4. Readability Scores of Seven Independent Readability Formulas for Original Versus Edited PEMs Included in the Present Study

Readability Formula	Original PEMs		Edited PEMs		Change in Mean	P Value
	Mean	SD	Mean	SD		
Flesch Reading Ease Score	52.9	6.9	68.8	5.6	15.9	P = 5.5E-13
Gunning Fog	12.7	1.7	8.6	1.4	−4.1	P = 1.5E-13
Flesch−Kincaid Grade Level	9.8	1.4	6.4	1.1	−3.4	P = 1.9E-13
The Coleman-Liau Index	11.7	1.0	10.0	0.8	−1.7	P = 5.2E-09
The SMOG Index	9.6	1.2	6.8	1.0	−2.9	P = 1.0E-12
Automated Readability Index	9.9	1.6	6.3	1.2	−3.6	P = 1.5E-13
Linsear Write Formula	10.2	2.1	5.9	1.1	−4.3	P = 2.0E-12

PEMs, patient education materials; SMOG, Simple Measure of Gobbledygook; SD, standard deviation.

be 15.8 ± 2.4 for original PEMs versus 11.1 ± 1.7 for edited PEMs ($P = 5.8 \times 10^{-13}$). Percentage of complex words was measured to be 17.6% ± 3.1% for original PEMs compared to 11.7% ± 2.8% for edited PEMs ($P = 7.2 \times 10^{-10}$). Numerical data regarding these variables are summarized in Table 5. All numerical data compared between original PEMs and edited PEMs differed significantly ($P < .01$).

Discussion

The primary findings of this study support our hypothesis and illustrate that a standardized method focused on reducing the usage of complex words and reducing sentence length to ≤15 words per sentence improves readability of PEMs across all 7 readability formulas. This current study not only shows that PEMs for knee pathology in orthopaedic sports medicine are written at a level well above the recommended reading level, but also, more importantly, proposes a simple standardized method that effectively improves readability of PEMs while preserving critical content. The standardized method for improving readability used in this study significantly improved the readability of all PEMs across all 7 independent readability formulas and significantly reduced numbers of words, number of words per sentence, characters per word, syllables per word, percentage of complex words, and number of complex words. This is a clinically impactful finding as improving the readability of PEMs directly translates to

enhanced patient health literacy which can lead to better patient outcomes.[23-25] Furthermore, the simplicity of the standardized method allows for it to easily be applied to other fields within orthopaedics, as well as other specialties within medicine, to improve health literacy on a wider scale.

Recommendations for improving readability of PEMs have existed for several decades. The prevailing sentiment of these suggestions is that it is essential to consider the reading skills of the target audience when creating PEMs. The most often cited technique for improving readability includes replacing complex medical jargon with simpler terms (Fig 2).[2,3,8,17,18,21,22] An example of simplifying word choice would be the replacement of the 4-syllable term "arthroscopy" with the 1-syllable word "scope."[8] Although both terms convey the same message, the latter is easier to understand and thus more accessible to the reader. In improving word choice, it has been recommended to use shorter words with fewer syllables.[1,8,18] Another often-suggested technique includes simplifying sentences to be more succinct and easier to understand.[1,3,8,17,18,21,22] Reducing length of sentences to 10 to 15 words was shown by one study to improve the reading level of 8 PEMs by an average of 1.41 grade levels.[2] This parallels the finding in the current study that limiting use of complex words and reducing sentence length to fewer than 15 words can effectively improve the reading level of PEMs by 3.13 grade levels according to

Table 5. Composite Descriptive Statistics Comparing Original Versus Edited PEMs Included in the Present Study

Measurement	Original PEMs		Edited PEMs		Change in Mean	P Value
	Mean	SD	Mean	SD		
Number of words (total)	1351.7	600.3	1215.5	584.4	−136.2	P = .00042
Number of words per sentence	15.8	2.4	11.1	1.7	−4.7	P = 5.8E-12
Mean characters per word	5.0	0.2	4.7	0.1	−0.3	P = 3.3E-11
Mean syllables per word	1.9	0.3	1.5	0.5	−0.4	P = .23
% of 3+ syllable words	17.60%	3.10%	11.70%	2.80%	5.9%	P = 7.2E-10
No. of 3+ syllable words	242.2	129.1	146.6	100.2	−95.6	P = 1.3E-7

PEMs, patient education materials; SD, standard deviation.

Problem Words and Suggested Alternatives	
Problem Words	**Suggested Alternative**
Anterior	Front
Beneficial	Helpful
Debilitating	Weakening
Examination	Check
Rehabilitate	Restore
Physician	Doctor
Adjacent	Next to
Incorporating	Blending, joining, mixing
Opportunities	Chances
Compress	Squeeze
On a regular basis	Regularly
Strategies	Plans
Subsequently	After
Deplete	Empty
Beneficial	Helpful
Components	Parts
Abrasions	Scratches
Inadvertent	Careless
Utilization	Use
Prioritize	Rank
Lacerations	Cuts
Occurrence	Event
Typically	Often
Alteration	Change
Emphasize	Stress
Internal	Inner
External	Outer

Fig 2. List of complex words, often containing medical jargon, and their suggested alternatives that can function to improve readability of patient education materials (PEMs).[17]

the Flesch–Kincaid Grade Level readability formula. Other recommended strategies for improving readability of PEMs include writing in active versus passive voice, using bulleted lists when appropriate, supplementing with visual illustrations, using traditional 12- to 14-point font size, and maintaining consistency in word choice (e.g., using only "surgery," "operation," or "procedure" instead of interchanging them).[1-3,8,22] Pitfalls that decrease readability, and should be avoided, include using all capital letters, italics, and nontraditional fonts and sans-serif fonts.[3,26] While many studies analyzing readability of orthopaedic PEMs suggest these improvements, few, if any, have investigate the ability for these strategies to effectively improve readability of PEMs.

Although the availability of PEMs has increased in past decades, there exists a remarkable discrepancy between the readability of the documents and the reading skills of target audience. Current literature has consistently demonstrated the readability of orthopaedic PEMs to be inappropriately high and well above the recommended sixth-grade reading level.[1-4,8,17,18] For many patients, this creates a barrier to understanding medical information and their own diagnoses. There exists ample literature describing the inappropriately high reading level of PEMs across many fields within orthopaedic surgery.[1-4,8,17,18] A 2008 study showed that PEMs published on the AAOS website had an average reading grade level of 10.4, and only 2% of the articles were written below the recommended sixth-grade reading level.[3,4] A re-evaluation of AAOS PEMs in 2015 still showed that only 3% of these articles were written at or below the sixth-grade reading level.[4,27] Recommendations for improving readability of PEMs have existed for several decades. The most often cited techniques include replacing complex medical jargon with simpler terms and shortening sentence length to 10-15 words per sentence.[2,3,8,17,18,21,22] These measures are supposed to create PEMs that are more accessible to the reader without sacrificing the critical content of the article.

More recent literature consistently displays that readability of PEMs continues to be a barrier for patients. An analysis of the readability of PEMs provided by the American Orthopaedic Society for Sports Medicine in 2018 found that all PEMs were written above the recommended sixth-grade reading level with 36% written above a twelfth-grade reading level.[17] In addition, a 2018 investigation of PEMs for hip arthroscopy found an average reading level of grade 12.79, with no individual websites containing information below an eighth-grade reading level.[1] Furthermore, a 2015 analysis of online foot and ankle PEMs produced by the AAOS, the American Orthopaedic Foot and Ankle Society, Medline Plus, and 11 academic centers found an average reading level of grade 10.1, with no organization or institution producing a reading level within the recommended range.[2] Thus, as these studies show, online PEMs currently require some degree of secondary education to properly understand the presented information. This limits the potential for improvement in health literacy and is a disservice to patients at large.

Inappropriately high reading levels of PEMs reduce both the accessibility and potential utility of these important opportunities for improving health literacy. Health literacy is vital for orthopaedic patients. Multiple studies have demonstrated an association between health literacy and patient expectation and outcomes and also have highlighted the importance of setting realistic expectations.[17,28,29] When patients do not have a complete understanding of their health information, they have been shown to ask fewer questions when meeting with physicians and express understanding when they are actually unsure.[17,30,31] Investigators have shown that, when health literacy is low, and patients lack a thorough understanding of their diagnosis and treatment plan, patients experience worse outcomes.[3,8-11] Poor health literacy has been associated

with more frequent hospital admissions, with longer stays in the hospital, greater risks for seeking emergency care, increased complications, reduced compliance, and more frequent missed appointments.[3,6,8-13] Not only does poor health literacy bring worse outcomes for the patient, but also it creates financial burden. Poor health literacy contributes an estimated $73 billion of additional burden to the U.S. health care system.[3] Estimates show that the health care cost of Medicaid for those with limited health literacy is approximately 4 times greater than those with adequate health literacy.[3,7] Poor health literacy is a pervasive issue in orthopaedics that results in worse patient outcomes but has the potential to be fixed with better patient education.

Limitations

There are several limitations of this study. The first is the lack of patient perception of improvement of readability. As objective, evidence-based equations were used to determine readability, individual patients were not recruited to evaluate subjective readability of PEMs. In addition, the PEMs were only taken from a single informational website. While this was done to improve consistency with regards to the writing style and content, there is the possibility that other sources of literature may present information in a more readable form. Since this website is endorsed by the AAOS and is used by a large number or patients and providers alike, it was determined that this would be a valuable resource to assess. A third limitation was that the readability of the original and edited PEMs used in this study was not tested by actual patients. This represents an area of focus of future studies in which actual patient comprehension can be measured before and after reading the PEMs.

Conclusions

A standardized method that reduces the use of ≥ 3 syllable words and ensures that sentence length is ≤ 15 words significantly reduces the reading-grade level of PEMs for sports-related knee injuries. Orthopaedic organizations and institutions should apply this simple standardized method when creating PEMs to enhance health literacy.

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