REVIEW ARTICLE

Orgasm and SCI: what do we know?

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Abstract

Study design narrative review

Objectives To determine the percentage of persons with SCI able to achieve orgasm and ejaculation, the associations between ejaculation and orgasm and the subjective and autonomic findings during these events, and the potential benefits with regards to spasticity.

Setting Two American medical centers

Methods Data bases were searched for the terms orgasm and SCI and ejaculation and SCI. Search criteria were human studies published in English from 1990 to 12/2/2016.

Results Approximately 50% of sexually active men and women report orgasmic ability after SCI. There is a relative inability of persons with complete lower motor neuron injuries affecting the sacral segments to achieve orgasm. Time to orgasm is longer in persons with SCIs than able-bodied (AB) persons. With orgasm, elevated blood pressure (BP) occurs after SCI in a similar fashion to AB persons. With penile vibratory stimulation and electroejaculation, BP elevation is common and prophylaxis is recommended in persons with injuries at T6 and above. Dry orgasm occurs approximately 13% of times in males. Midodrine, vibratory stimulation, clitoral vacuum suction, and 4-aminopyridine may improve orgasmic potential.

Conclusions Depending on level and severity of injury, persons with SCIs can achieve orgasm. Sympathetically mediated changes occur during sexual response with culmination at orgasm. Future research should address benefits of orgasm. Additionally, inherent biases associated with studying orgasm must be considered.

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Introduction

Sexuality is an important concern for persons with and without spinal cord injuries (SCIs) [1]. Desire for affection and intimacy, gender expression and preferences, participation in sexual activities, arousal, and orgasm are all components of sexuality. Unfortunately, sexual satisfaction, frequency of activities, and overall interest decrease after SCI [2–7].

The sexual response cycle generally culminates with orgasm. However, as per a recent publication, “The definition of orgasm is not an easy task. The way of experiencing it is subjective” [8]. In able-bodied women orgasm has been defined as “a variable, transient peak sensation of intense pleasure, creating an altered state of consciousness, usually accompanied by involuntary, rhythmic contractions of the pelvic striated circumvaginal musculature, with concomitant uterine and anal contractions and myotonia that resolves the sexually induced vasocongestion (sometimes only partially), usually with an induction of well-being and contentment” [9]. In men, orgasm has been described as “the result of cerebral processing of pudendal nerve sensory

stimuli resulting from increased pressure in the posterior urethra, sensory stimuli arising from the verumontanum and contraction of the urethral bulb and accessory sexual organs [10].

Orgasm is well-known to occur in persons with SCIs [2–7, 11, 12]; however, similar to able-bodied (AB) persons, most studies rely on self-report data and infrequently, concomitant measure of autonomic responses [13]. Unfortunately, the potential for orgasm is often disregarded after SCI and orgasm is often equated with ejaculation. Significant research assesses ejaculation after SCI and its benefits, primarily decreased spasticity, but sparse data examines orgasm. Opinions also differ regarding the association and frequency of autonomic dysreflexia (AD) with orgasm [13, 14]. In order to optimize the ability to achieve orgasm in persons with SCIs, it is important to understand its characteristics. The goals of this review are therefore to (1) determine the methods and ability of persons with varying patterns of SCIs to achieve orgasm along with associated subjective and autonomic responses and (2) determine the associations between orgasm and ejaculation and effects on spasticity. For information regarding the neurophysiologic aspects, the reader is referred to a recent review on the neurologic control of orgasm with regards to spinal cord lesions [15].

Methods

A search of Pub Med, CINAHL Complete and the Cochrane databases was conducted with results detailed in Fig. 1. Search criteria included English language, 1990 to 12/2/2016, only human studies. Specific questions included

What percent of persons with SCIs can achieve orgasms and are there subgroups with more capacity to achieve orgasm? What techniques used to achieve orgasm? What are the autonomic and subjective characteristics of orgasm and ejaculation and do they always coexist? What is known about ejaculation and/or orgasm and spasticity? Search terms included (1) orgasm and SCI, (2) ejaculation and SCI. The complete list of abstracts was then reviewed for relevance to the research questions and case reports, reviews, met analyses and irrelevant and duplicative abstracts were removed. Original articles were then obtained from this revised list of abstracts and 53 articles were reviewed independently by both authors. After review of the complete articles, 11 were deleted due to irrelevance to the questions or not meeting review criteria. A total of 42 articles were placed in appropriate tables to determine their relevance to specific research questions, and both authors concurred regarding individual points. After the initial review, just prior to study submission, one additional paper was added that was identified as relevant [16]. When articles were particularly germane to the topic and included independent information but the same subjects, all references were listed in the same row on the table. Additionally, if a single article pertained to multiple tables, appropriate information was included on all tables. Due to the volume of relevant information, all tables are included as supplementary material that are available on line.

Results

Studies reporting ability to achieve orgasm

Twenty-three studies addressing the percentage of persons with SCI with the ability to achieve orgasm and techniques used to achieve orgasm are presented in Supplementary Table 1 [2–7, 11, 12, 16–30]. Among these, 15 were cross sectional questionnaire or interview studies [2–7, 16, 19, 20, 22–24, 26, 28, 30]. Two studies discussed in three separate papers were laboratory based controlled analyses of the ability to achieve orgasm [18, 21, 27]. Two double-blind placebo controlled clinical trials assessed the impact of the treatment on orgasmic function as a secondary outcome via questionnaire [17, 29]. Two studies assessed potentially orgasmic sensations during ejaculation using penile vibratory stimulation (PVS) [12, 25] while one prospective study evaluated the ability to achieve orgasm with PVS and midodrine [11].

One shortfall identified in these reports is that generally to achieve orgasm participation in sexual activity is required and sexual activity can cease post SCI. This issue is often not discussed; nor is there a consistent definition or discussion of what comprises sexual activity. Many of the

Fig. 1 Search results

reports provide inadequate data to determine the association of orgasm with specific injury patterns, many studies focus on intercourse, and in males studies often limit their discussion to the occurrence of ejaculation. Although the number of men with SCI is approximately 4 times that of women, there is less information available about male orgasm. In the male population, there were a total 604 men studied of which 539 were sexually active. Of these 241 reported they achieved orgasm; hence, 40% of all males and 45% of sexually active males achieved orgasm. In the female population, there were 1544 women studied of which 1168 were sexually active and 654 reported orgasms. Thus 42% of all females and 56% of sexually active females reported orgasm. If we combine all data, a total of 942/2241 (42%) of all persons with SCIs reported having orgasms or 942/1811 (52%) sexually active persons with SCIs.

Reports assessing the impact of treatments on the ability to achieve orgasm showed 59% of men of 158 men who had failed to ejaculate at home or during baseline PVS could have orgasm with the addition of midodrine [11]. This study was not blinded and midodrine dose was increased up to 30 mg in order to optimize the likelihood of orgasm, thus the issue of bias must be considered. A prospective, unblinded study of 170 men receiving sildenafil noted that men with preexisting orgasms were 5 times as likely as those without to respond to the drug [17]. Moreover, their abilities to achieve orgasm, as measured by the International Index of Erectile Function (IIEF), improved with use of sildenafil [17]. In two double-blind placebo-controlled studies (DBPC) with 357 male and 58 female subjects, administration of the drug 4-aminopyridine, for spasticity, showed a significant increase in the orgasm domain of the IIEF in one study out of two; however, there were no significant changes in females [29].

Regarding techniques to achieve orgasm, only one questionnaire study in females detailed where women stimulated themselves to achieve orgasm, noting the stimulus was generally genital or genital plus breast [3]. In contrast, in a laboratory based study [18] all women chose genital stimulation. In males with SCIs, although it is often indicated that stimulation around the level of injury can be arousing, published studies have identified only the use of genital stimulation to achieve orgasm [21]. Another questionnaire study indicated approximately 80% of 199 men studied [23] reported trying to achieve ejaculation post SCI and of these 26% reported using hand stimulation, 21% engaged in intercourse and 14% used vibratory stimulation.

The occurrence of orgasm with specific types of injuries is infrequently addressed. One questionnaire study of males indicated 51% of 16 with complete tetraplegia, 66% of 6 with incomplete tetraplegia, 25% of 12 with complete paraplegia and 75% of 4 with incomplete paraplegia had orgasms [4]. In another report [24] 59% of 44 males with

AIS A, 79% of 14 with AIS B, 55% of 11 with AIS C, and 74% of 23 with AIS D SCIs had orgasms. However, neither report limited their assessments to sexually active persons, which is generally a prerequisite to orgasm, and this issue was handled differently in the reports. In the first paper [4] there is a column attributed to, 'do not know' if they had orgasm. If we surmise these men were not sexually active, the rate of orgasm goes up in men with complete tetraplegia to 66 and 27% in men with complete paraplegia. In contrast, in the second paper [24] if we only consider the percent of men that said they were sexually active, then 87% of AIS A, 92% of AIS B, 100% of AIS C, and over 100% (actually 113%) of AIS D subjects would have reported orgasms. Similarly, the issue of not participating in sexual activities or not knowing whether the person can achieve specific sexual responses is important in female studies. In a questionnaire study of 25 females, 40% of 5 with complete tetraplegia reported orgasm while 40% did not know, 77% of 9 with incomplete tetraplegia reported orgasm whereas 11% did not know, 25% of 4 women with complete paraplegia reported orgasm while 50% did not know, and 71% of 7 women with incomplete paraplegia reported orgasm whereas 14% did not know [5]. Clearly, these analyses identify the issues of over and underreporting associated with retrospective self-report questionnaire studies.

Laboratory studies with detailed neurologic examination of persons with SCIs and able-bodied controls have been performed to address the deficiencies of self-report data. Men [21] and women [18] with SCI (50% of 45; 44% of 52) were significantly less likely than AB controls (100% of 16; 100% of 21) to achieve orgasm in a laboratory ($p < .001$; $p = .001$). With respect to the pattern of SCI, of 45 men, 50% of 29 men with complete injuries and 84% of 16 men with incomplete injuries reported orgasmic ability at home ($p = .018$) while 28% of 29 men with complete injuries and 79% of 16 men with incomplete injuries reported orgasms in the laboratory ($p < .001$). Of men with complete lower motor neuron (LMN) injury affecting their sacral segments none (0/4) reported orgasm at home compared to 68% of 41 with all other levels and degrees of injury ($p = .007$) and 0/4 vs. 55% of 41 had orgasms in the laboratory ($p = .04$) [21]. Similarly, of 62 females [18], only 17% or 1 of 6 women with complete LMN dysfunction affecting their S2–S5 spinal segment reported orgasm at home vs. 59% of 56 women with all other degrees of SCI ($p = .048$), with 17% of 6 vs. 46% of 56 reporting orgasm in the lab ($p = .16$). Although the potential for bias remains as orgasm is a subjective phenomenon, these reports have the benefit of laboratory-based data and AB controls. Collectively, these reports [18, 21] document there is a decreased ability to achieve orgasm after SCI and that, within the SCI population, both women and men with complete LMN injuries affecting their sacral segments are significantly less

likely to achieve orgasm than individuals with all other levels and degrees of SCIs.

In another report [11] the occurrence of orgasm during ejaculation was described. A total of 59% of 158 men who had failed to ejaculate with PVS alone reported orgasm with the addition of midodrine. Furthermore, the perception of orgasm was associated with antegrade ejaculation. Of 70 with antegrade ejaculation, 99% reported orgasm compared to 54% of 32 who did not achieve antegrade ejaculation. Injuries below T10, LMN lesions and a lack of somatic responses with stimulation were significantly related to the absence of orgasm and 13% had dry orgasm. Courtois [12, 25] performed 2 studies which described sensations associated with orgasm; thus, these studies are included in Supplementary Table 1 as the word orgasm is used in the title; however, the word orgasm was not used in discussion with the subjects. Rather, events associated with ejaculation were reported as the outcome, therefore, this information is discussed under ejaculation.

Taken together these studies indicate that it is possible to achieve orgasm after SCI and that the use of midodrine, sildenafil and 4-aminopyridine may be pro-orgasmic. Persons with complete LMN injuries affecting the sacral segments are less likely than persons with all other levels and degrees of SCI to achieve orgasm.

Studies reporting ejaculation

Studies related to the ability to achieve ejaculation are in Supplementary Table 2 [25, 31–40]. There is one cross sectional study querying the natural ability to ejaculate [40] and seven assessing the efficacy of PVS to achieve ejaculation in men with SCIs [31, 32, 34–37, 39] including three retrospective chart reviews [35–37]. There was one double-blind placebo controlled (DBPC) clinical trial that discussed ejaculation with the treatment of erectile dysfunction [38] and one report that discussed the negative impact of the baclofen pump, an antispasticity therapy, on ejaculation [33]. The use of 100 Hz frequency and 2.5 mm of amplitude for PVS was shown to have optimal efficacy for producing ejaculation [31]. Those subjects who had cord lesions at and below T10 were more likely to ejaculate if they had an intact hip flexion or bulbocavernosus reflex (BCR); however, without these reflexes ejaculation was unlikely [32, 35]. In a retrospective review of 123 patients who underwent 204 trials of PVS [35], based upon level of injury, subjects with cervical injuries ejaculated 71% of the time, those with T1–T6 ejaculated 73% of the time and those with T7–T12 injuries ejaculated 35% of the time. For those patients who were below the cervical level, if there was no hip flexion or BCR reflex, 0/21 patients achieved ejaculation. Furthermore, patients with a penile prosthesis were less likely to achieve ejaculation [32] and block of the

dorsal penile nerve prevented ejaculation [34] as did baclofen pump implantation [33]. In a retrospective review of 297 men who underwent 965 PVS trials [34], the use of 2 vibrators increased the percentage of men ejaculating by 22% as compared to just one vibrator. The same group also reported [41] an ejaculatory success rate of 77% in 30 men through the use of the vibrect-X3 (Reflexonic, Frederick, MD, USA) which is designed to stimulate both sides of the penis simultaneously. Soler et al. [39] reported results of the addition of midodrine to stimulate ejaculation in men who were unable to achieve ejaculation naturally or with PVS. Of 158 males, 65% achieved retrograde or antegrade ejaculation. These results were broken down as 62% of men with tetraplegia, 69% with paraplegia above T6, 46% with paraplegia T7–T10 and 79% with paraplegia at or below T11.

Courtois et al. [25, 37] reported results of a progressive protocol to stimulate ejaculation consisting of masturbation (10 min masturbation, 10 min of video alone, 10 min of both) followed by PVS (Ferticare vibrator at 120 Hz, 3 mm amplitude used for 3 min stim and 1 min of rest with max of six trials). If this did not produce ejaculation, PVS was coupled with midodrine (5 mg ingested 30 min before PVS protocol, increased by 5 mg with each negative test up to 30 mg) to achieve ejaculation. Tests were performed a week apart and continued until men achieved either retrograde and or antegrade ejaculation. In 45 of 60 men who completed the protocol and were evaluated retrospectively, 11% ejaculated with natural stimulation, 56% ejaculated with the addition of PVS and 22% achieved ejaculation with addition of midodrine [37]. Prospectively, in 81 men [25] these techniques resulted in 91% achieving ejaculation; however, neither report documents whether the men reported orgasm. In the prospective study, we do not know the breakdown of complete vs. incomplete injuries by level; however, 49% of subjects had complete injuries and 51% incomplete. Ejaculation occurred in 83% of men with C2–T2 lesions, 93% with T3–T6 lesions, 100% with T7–T10 lesions, 67% with T11–L2 lesions, and 100% with lesions at L3 and below.

The studies of Soler and Courtois both had a relatively large number of subjects but were not controlled or blinded. In contrast, in a small double-blind placebo-controlled study of 20 men with SCIs [42] above T10 who underwent one PVS trial followed by 3 subsequent trials in association with midodrine up to a maximal dose of 22.5 mg, the authors reported that 1/10 subjects from the midodrine group and 2/10 from the placebo group reached ejaculation. These results are in contrast to others. Thus, the overall low success rate in conjunction with the small sample size must be considered along with the impact of the informed consent process and nocebo and placebo effects and potential research bias all of these studies. In summary, these reports

demonstrate that men with complete SCIs can experience ejaculation and it is possible to improve the ability of men with SCIs to achieve ejaculation. However, the lack of a question specifically asking about orgasm in the Courtois reports [12, 25, 37], the lack of documentation of ejaculation in the Sipski report [21] and the 13% occurrence of dry orgasm in the Soler report [11] highlight the potential inaccuracies in equating orgasm and ejaculation in men with SCIs.

Characteristics of orgasm and ejaculation

Supplementary Table 3 documents studies with data regarding the subjective and autonomic characteristics of orgasm and ejaculation. With regards to orgasmic latency, in one study with n of 231 it is reported that about 50% of women were orgasmic after injury and of these 43 reported time to achieve orgasm after SCI was longer than prior to injury [3]. This was also demonstrated in a laboratory study [18]. Mean time to orgasm was significantly greater in women with SCIs ($n = 62$) than AB women ($n = 21$) (26 min vs. 16 min); however, in men with SCIs ($n = 45$) vs. AB men ($n = 16$) (19 min vs. 16 min) this difference was not statistically significant [21].

Intensity of orgasm was less in 43% of 231 women in the aforementioned report, [3] whereas, Ferreiro-Velasco et al. [19] reported 72% of 19 women who were orgasmic after SCI had more difficulty achieving less pleasurable orgasms. Only one study [5] assessed multiple orgasms and reported that 6 of 11 women who were orgasmic after SCI had multiple orgasms. In a laboratory based study [18], descriptions of orgasmic sensations could not be distinguished between AB women vs. women with complete or incomplete SCIs. In a questionnaire study of 234 orgasmic women with SCIs [28], 8% reported orgasms were the same as before the injury. Twenty-five percent reported positive sensations including comments like “being in heaven”, 13% were satisfied with orgasms and 31% reported they were relaxing. Results were conflicting however, in that, despite reporting orgasms, 3% reported unpleasant sensations in association with orgasm and 8% reported that they have not experienced orgasm after SCI.

Sensations associated with ejaculation were studied retrospectively in 45 men [37]. Spasms, shivering, goose bumps, hot flushes, pleasure and a feeling of imminent ejaculation were more common during ejaculatory than non-ejaculatory events and more likely with the use of midodrine. Headaches were only reported during positive tests and were more likely with midodrine [37]. Sensations were also assessed in 81 men prospectively with or without ejaculation [25]. In this study, 11 questions related to autonomic hyperreflexia, 9 to general autonomic arousal,

8 to muscular responses and 5 were about cardiovascular and respiratory responses. Not surprisingly, increased sensations were present when ejaculation occurred. Moreover, it was reported that increased sensations were noted with ejaculation when AD, as defined by an increase in blood pressure (BP) over 20 mmHg occurred. Bird et al. [35] reported on “somatic responses” of 44 men during PVS including abdominal contractions below the injury level, thigh abduction and adduction, lower extremity spasms, lower extremity withdrawal and piloerection. These responses were compared during 204 trials to determine which responses occurred with and without ejaculation. Among the entire population, somatic responses were more often seen when ejaculation occurred (71% vs. 29%; $p = 0.011$). Specifically, piloerection (37% vs. 17%; $p = 0.03$), withdrawal response (26% vs. 7%; $p = 0.004$) and extremity spasms (55% vs. 27%; $p = 0.021$) were significantly more common with procedures resulting in ejaculation.

There were only three groups that specifically assessed the autonomic responses associated with orgasm or ejaculation with concomitant orgasm. In the two laboratory based studies [18, 21] of orgasm, heart rate (HR), respiratory rate (RR) and BP were monitored every three minutes and at orgasm in SCIs ($N = 45$ M, $N = 27$ F) and AB control subjects ($N = 16$ M, $N = 21$ F). In females, baseline and orgasm HR and BP were statistically similar between SCI and AB subjects. Mean HR at orgasm was 100 for AB women and 96 for women with SCIs while systolic (S) BP at orgasm was 136 mmHg for AB and 137 mmHg for SCI and diastolic (D) BP was 75 mmHg for SCI and 71 mmHg for AB women. Systolic BP and HR were statistically higher in both AB and SCI women at orgasm compared to baseline; however, DBP was not. In males SBP and DBP were significantly lower at baseline in SCI subjects compared to controls; however, HR was similar between SCI and AB subjects. Similar to women, autonomic parameters at orgasm were similar between AB and SCI subjects. In males, mean HR at orgasm was 81 for SCI subjects and 90 for AB subjects while SBP was 157 mmHg in AB subjects and 143 mmHg in SCI subjects and DBP was 78 mmHg in SCI subjects and 92 mmHg in AB subjects. Of note, in a prospective laboratory-based study of a subgroup of 25 women with SCI above T6 from the larger group [18, 27], a preplanned treatment for dysreflexia was developed but not utilized as no women were clinically dysreflexic during the assessment. Similarly, of 24 men at T6 and above [21] no clinically significant dysreflexia was noted.

In two separate reports, Courtois [12, 37] documented a significant increase in SBP to 148–153 mmHg at ejaculation with the use of midodrine vs. 113–118 mmHg at baseline while DBP increased from 72–69 mmHg at baseline to 85–91 mmHg at ejaculation and HR decreased from 72 to 63 mmHg. These changes were not seen in tests where

ejaculation was not achieved implying that differences in SBP were specifically related to the occurrence of ejaculation (which Courtois equated with orgasm).

Soler et al. [39] also compared the effects of ejaculation and orgasm on BP. They documented the BP changes associated with stimulation of ejaculation through the use of PVS in association with midodrine. Of 158 men with SCIs, complete files were available regarding BP in 133 individuals. Men were divided into groups as previously described. Based upon these groups, SBP was progressively greater with higher lesions. Maximum BP and HR in men with tetraplegia while on PVS with midodrine was 189/100 mmHg and 54 compared to mean baseline readings of 128/70 mmHg and 67. For men with lesions at T6 and above max BP was 174/95 mmHg with HR 56 compared to a baseline of 130/71 mmHg and 70. For men with lesions between T7–10 readings were 156/84 mmHg and 62 vs. 126/71 mmHg and 70 and for men with lesions below T10 they were 140/84 mmHg and 63 vs. 128/72 mmHg and 72.

Other studies have described BP responses associated solely with ejaculation and not orgasm in smaller groups of subjects or without providing information about other aspects of ejaculation. In a series of 30 subjects of which 26 had injuries at T6 and above, using the vibraerect [41], highest BP at ejaculation was reported as 155/94 mmHg. In another study [43], 11 men of unknown injury levels were compared during PVS vs. EEJ with peak BP of 162/95 mmHg during PVS and 169/91 mmHg during EEJ. In contrast, in a series of 13 men, the occurrence of autonomic dysreflexia (AD) during PVS performed for sperm retrieval was reported using the criteria of a 20 mmHg increase in BP [44] and it was noted that 3 of 13 men with lesions at T6 and above had AD during PVS. Systolic and DBP was reported to be significantly higher in the subgroup of 8 men with cervical lesions at ejaculation vs. rest (190/129 vs. 83/55 mmHg; $p < 0.001$), but not in the 5 men with thoracic lesions. Men with complete injuries were unaware of these BP changes [45]. Moreover 5 of these subjects were noted to have bradycardia in conjunction with PVS induced ejaculation [45] whereas 7 other subjects had other arrhythmias. In a small trial [46], 6 men with SCI above T6 underwent PVS with and without the addition of prazosin to treat dysreflexia. The study reported that 1 mg of prazosin the night before, with a repeat dose 20 min before stimulation, decreased the maximum increase in SBP by 40 mmHg.

Nifedipine has also been utilized to pretreat men with SCIs undergoing EEJ [47]. In a study of 10 men who had AD during EEJ, sublingual nifedipine reduced mean SBP from 163 to 143 mmHg along with decreasing mean DBP from 98 to 80 mmHg.

Association of orgasm and ejaculation

With regards to the occurrence of orgasm and ejaculation, in Soler et al.'s report [11] 99% of 70 men who achieved anterograde ejaculation reported orgasm, compared to 54% of 32 men with only reflex ejaculation. Moreover, they noted that 13% of 158 men reported dry orgasm. With regards to breakdown among subgroups of orgasmic men with complete tetraplegia [4], 38% of 8 ejaculated, 28% did not ejaculate, and 25% did not know if they ejaculated. With incomplete tetraplegia, 50% of 4 subjects with orgasms reported ejaculation while the other 50% did not ejaculate. With complete paraplegia, 2 of 3 orgasmic subjects reported no ejaculation while the other did not know, and 3 orgasmic subjects with incomplete paraplegia all had concomitant ejaculation. In an online study [23] it was reported that 48% of 199 of men had achieved ejaculation post injury and 41% had orgasms. Of those men who had achieved orgasm, 89 % reported ejaculations.

Spasticity and ejaculation

Four small studies [48–51] (see Supplementary Table 4) have assessed the effects of ejaculation on spasticity via PVS or electroejaculation (EEJ). Using EEJ, Halstead and Seager performed assessments of spasticity pre- and post-EEJ in a total of 23 subjects including 3 females [48, 49]. These reports demonstrated the majority of subjects had over 50% relief of spasticity with an effect lasting approximately 8 h. In another study of 9 men [50] assessing the impact of PVS on spasticity, EMG data showed a significant decrease in spasms up to three hours post PVS whereas Ashworth data showed a decrease in spasticity after ejaculation lasting an average 8 h. Moreover, in another report of 10 men with SCIs who were monitored at baseline, 3, 5, 24 and 48 h after PVS [51], there was a significant decrease in spasticity as measured using the Ashworth scale both at 3 and 6 h post stimulation.

Discussion

This review documents the current state of our clinical knowledge regarding orgasm and ejaculation after SCI. Overall the ability to achieve orgasm is documented in about 50% of persons with SCIs with a larger percentage of women reporting the ability to achieve orgasm than men. However, overall there are limited studies available and the number of subjects in many reports is small. There is generally insufficient detail paid to whether subjects are actually sexually active when they are asked about orgasmic capabilities. A variety of questionnaires, either validated or non-validated, were used, in addition to online, phone or

semi-structured interviews, thus reports are retrospective and subject to recall bias. There is limited data regarding specific injury characteristics and subsequently limited attempts to document the specific effects of injury patterns on sexual responses. There is a divergence in study design between various reports and there may be a bias related to desire for positive outcomes, such as in the studies [11, 25, 37, 39] that use PVS with midodrine to facilitate the likelihood of ejaculation. Nevertheless, this review compiles the published data on orgasm and ejaculation in individuals with SCI and provides further documentation of the potential for persons with SCI to safely achieve orgasm after SCI.

Some of these data were obtained in the general SCI population via questionnaire, while other data were obtained in the laboratory. In addition to positive biases, these data may also include negative biases that need to be considered in treating persons with SCIs. Too much focus may be placed on ejaculation in men, and this may impede their ability to perceive orgasm. Persons with SCIs are on multiple medications that can negatively impact sexual function such as SSRIs, baclofen, alpha blockers and anti-epileptic medications and one report [26] noted that 18% of subjects were on antidepressants. Thus, the actual capacity of persons with SCIs to achieve orgasm is probably higher. Moreover, there have been minimal attempts and clinical trials dedicated to improving orgasmic function in persons with SCI [52]. There does appear to be a subgroup of persons with SCI that are unable to achieve genitally focused orgasm, specifically, those persons with complete LMN injuries affecting their sacral segments. Unfortunately, this information is not well known by clinicians in the SCI field; and the use of the bulbocavernosus reflex and the anal wink reflexes which document the type of neuron injury affecting S3–5 are inconsistent. In order to improve or sustain the ability of persons with SCIs to achieve orgasm, it would be beneficial for clinicians to consider persons with SCIs interest in sex and consider avoiding medications with significant negative side effects on sexual function.

With regards to the subjective findings associated with orgasm, this review suggests that it takes longer for persons with SCIs to achieve orgasm, thus persons with SCI may “give up” prematurely during sex with partners or during masturbation. In one report [18], the subjective characteristics of orgasm could not be distinguished between AB and SCI subjects. In another, a specific assessment of the physiologic characteristics of orgasm was addressed with a goal of developing a questionnaire to assess orgasm [12]; however, positive sensations were not elicited, the items chosen were generally of a negative nature, and the term orgasm was not used. Based upon this review, it is important to consider the potential placebo and nocebo effects

communication may have on patients when discussing orgasm; moreover, this must be considered in clinical care and future studies. It is important for clinicians to educate their patients about the potential to achieve orgasm and to consider the potential bias in their own communication. Further studies of sexual function should carefully take the issue of bias into account, ensuring that attention to proper controls and optimal methodology such as double-blind, placebo-controlled treatments are utilized when possible.

Based upon the review, as demonstrated by Soler et al. [39], the terms orgasm and ejaculation cannot be equated. Thus, it is suggested that in the future both ejaculation and orgasm are considered and addressed separately in clinical care and research. A standardized method to do so is described in the International Standards for the Assessment of Autonomic Function after SCI [53, 54] and the International Spinal Cord Injury Male and Female Basic Data Sets Version 2.0 [55]. Six of the papers identified as part of this review but not included in tables [53–58] discussed formats to document sexual response. Use of the ISAFSCI [53, 54] for documentation of the impact of SCI on sexual response should help with identifying persons with SCIs abilities to achieve orgasm. Additionally, the International SCI Male and Female Sexual Function Data Sets [55] may be useful to monitor the effects of various treatments on orgasmic function through time.

Blood pressure increases in the SCI population with orgasm and there are further increases in BP associated with procedures such as PVS and EEJ. On the other hand, review of autonomic responses in the studies specifically assessing orgasm [18, 21, 27], revealed elevations in BP were similar between AB and SCI subjects. The studies that documented the greatest increase in BP with PVS occurred in small series [44, 45, 59] through the use of continuous BP monitoring which may be more sensitive in detecting BP changes; however, the significance of a transient increase in BP is uncertain. The current definition of AD is characterized as a 20 mm Hg increase in BP. This definition was determined clinically and by consensus [14, 53] and refinement of the definition of AD such as describing the length of time it needs to be present in order to classify a patient as dysreflexic seems appropriate.

With regards to potential benefits of orgasm, another important finding in this review is the reported decreased spasticity with orgasm along with the known inhibitory effect of the antispasticity medication, baclofen, on orgasm. Further studies to confirm the relationship and benefits of orgasm on spasticity and general motor function would be useful and contribute to our knowledge about the neurophysiology of orgasm and spasticity. Inclusion of females into studies of any potential benefits of orgasm on spasticity is also important. Moreover, future studies should pursue

whether there are other benefits of regular ejaculation in areas such as increasing bladder capacity [60].

Based upon the physiologic characteristics of orgasm, it is generally associated with sympathetic activation followed by a parasympathetic response. By considering the neuroanatomy of the sympathetic chains and their connection at the ganglion imparis, a neurophysiologic model of orgasm that may help explain the decrease in spasticity can be envisioned [15]. Progressively increased sympathetic stimulation results in anterograde and retrograde impulses traveling in the lumbosacral area eventually reaching a threshold where the spinal ejaculation generator responds [61, 62] with additional neurologic impulses resulting in ejaculation in males along with the rhythmic contractions and events associated with orgasm in both sexes. Impulses could be sent retrograde and anterograde to both the brainstem and the ganglion imparis and there may be a resultant feedback loop around the genitals. In males the occurrence of ejaculation and associated cortical inhibition of the reflex would break the cycle; however, in females due to the lack of ejaculation, this loop may continue to circle in the genital area causing multiple orgasms. Based upon sympathetic neuroplasticity [63] retrograde transmission up the sympathetic chain could explain the occurrence of orgasm post SCI. This would be followed by a parasympathetic response and the resultant resolution phase. This mechanism could be similar in the AB population and after SCI.

To optimize the potential for maintenance of orgasm after SCI, it is important to utilize specific guidelines during patient care [64]. The clinician must determine and communicate the likely impact of the SCI on a person's responses and provide education regarding the impacts of concomitant issues such as spasticity, bladder and bowel function. Then if the individual reports sexual concerns, the clinician should consider decreasing medications with negative impacts on sexual function and consider adding other medications such as PDE5 inhibitors. Additionally, devices such as use of vibratory stimulation or the EROS [52] have recently been shown efficacious in treating neurogenic orgasmic dysfunction in women and medications such as midodrine [11] may be beneficial to improve orgasmic ability in persons with SCIs.

With regards to the issue of BP during orgasm, while there may be risks of elevated BP associated with sexual arousal to orgasm in the SCI population above T6, the majority of studies showing dangerous elevations in BP have been performed in conjunction with assisted ejaculation (PVS or EEJ) and without AB controls, thus the anxiety associated with experiencing these procedures in the presence of a clinician and the impact on BP must be considered. In contrast, in AB persons, orgasm induces a generalized autonomic response that includes increases in

BP, HR and respiration and similar findings were found in SCI subjects achieving orgasm in a laboratory. Based upon these results, we believe general education for persons with injury levels at T6 about the potential for dysreflexia should be performed. Then, if complaints of dysreflexia are present the clinician should consider all potential sources and if necessary provide prophylactic medication to treat dysreflexia in association with sexual activity.

In conclusion, data show orgasm naturally occurs in approximately 50% of the SCI population and is generally safe. Benefits of orgasm such as decreased spasticity should be studied in the future. Additionally, studies must consider that both nocebo and placebo effects are possible when addressing recovery of autonomic or somatic responses after SCI and how these effects can bias results.

Compliance with ethical standards

Conflict of interest The authors declare that they have no competing interests.

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