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Predonation Health-Related Quality of Life Scores Predict Time to Recovery in Hematopoietic Stem Cell Donors

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A B S T R A C T

The physical reactions to hematopoietic stem cell donation have been extensively studied, but less is known about factors that predict poorer donation experiences. The aim of this prospective study was to examine demographic and health-related quality of life (HRQOL) factors that might be associated with recovery and side effects. We also described the changes in HRQOL during the donation process. In total, 275 peripheral blood stem cell (PBSC) and 37 bone marrow (BM) consecutive donors completed the SF-36 questionnaire predonation and 4 weeks, and 3 months postdonation. Predonation HRQOL markers were the strongest predictors of time to recovery. Poorer predonation physical health was associated with longer recovery ($P = .017$) and certain side effects in PBSC donors. Poorer predonation mental health was associated with longer recovery in BM donors ($P = .03$) and pain after PBSC donation ($P = .003$). Physical HRQOL scores declined significantly from predonation to 4 weeks postdonation. This was shown both for PBSC and BM donors ($P < .001$ and $P = .009$, respectively), but the decline was much greater for BM donors. There was a return to predonation HRQOL values 3 months after donation in both groups with values well above the mean of the general population ($P < .001$).

INTRODUCTION

Hematopoietic stem cell transplantation is a curative procedure for life-threatening hematological diseases. During the last decade, peripheral blood stem cells (PBSCs) have replaced bone marrow (BM) as the main source of hematopoietic stem cells. Although the donation process is generally considered safe, side effects are a known risk, and care must be taken to minimize the potential of harm to donors.

Common side effects of BM and PBSC donation are well known [1-6], although studies examining which groups of donors are at increased risk are limited [3,5-13]. The latter is important because strategies to enhance donor safety should be based on findings from these studies and could result in a more personalized approach to higher risk groups. Research in orthopedic surgery has shown a significant relationship between preoperative health-related quality of life (HRQOL) and recovery [14,15]. Specifically, negative mood was shown to exacerbate pain. Given that pain is the most common side effect in the peridonation period, investigation into the relationship between predonation HRQOL and recovery may also be relevant in this setting.

In this prospective study, we aimed to identify the factors that influence donor recovery in a formal manner and those that are most commonly associated with certain side effects. We included both demographic factors and predonation HRQOL scores using the Short-Form 36 Health Survey (SF-36) questionnaire. We also describe the changes in HRQOL predonation and up until 3 months after donation and compare HRQOL between PBSC and BM donors.

METHODS

Study Population

The study population was composed of unrelated donors from the United Kingdom whose BM or granulocyte colony-stimulating factor (G-CSF)-mobilized PBSC donation was facilitated by Anthony Nolan between February and November 2013. All donors passed a rigorous physical eligibility screening (according to World Marrow Donor Association

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recommendations [16]) and were at least 16 years of age with a weight of at least 50 kg and a body mass index (BMI) < 35 for BM donors and <40 for PBSC donors. Donors gave informed consent for the donation process as per normal practice as well as additional informed consent for the HRQOL assessment questionnaires. Ethical approval was obtained from the registry's institutional review board.

Stem Cell Collection Methods

All PBSC donors were mobilized with lenograstim (glycosylated G-CSF; Chugai Pharma, London, UK), which was given at a once-daily dose of 10 μg/kg subcutaneously ± 10% for 4 consecutive days, and apheresis was commenced on day 5. A maximum of 2 apheresis procedures was performed. Donors who donated BM underwent harvest from both iliac crests under general anesthesia. In line with World Marrow Donor Association guidelines, no more than 20 mL/kg donor weight was extracted. Both types of donation were carried out in 1 of 4 collection centers.

Data Collection

Donors were recruited at the time of the donor's medical evaluation, which took place on average 17 days (range, 8 to 30) before donation. Data collection continued on day −4, day −3, and day −2 before donation for PBSC donors and on the day of collection for both types of participants (day 0). We subsequently contacted BM and PBSC donors via telephone 2 or 3 days after donation. Donors were contacted again using an online questionnaire 1 week after donation and weekly thereafter up until complete recovery.

Complete recovery was determined on the day 2 to 3 or weekly questionnaire and defined as the absence of ongoing symptoms as well as return to predonation health. The assessment at each time point involved a self-reported checklist of specific side effects, including allergy, anorexia, back pain, bleeding, bruising, dizziness, fatigue, fever, headache, infection, injection site reaction, insomnia, myalgia, nausea, any other pain, and vomiting. Each side effect was scored using the Common Terminology Criteria for Adverse Events (CTCAE) toxicity index. Demographic factors analyzed as potential influencing factors of time to recovery or side effects were gender, age, BMI, support network (number of dependents, marital status), and being a blood donor.

Health-Related Quality of Life

HRQOL was measured using the SF-36 questionnaire, given to donors (either by post or e-mail) before donation (before the start of G-CSF for PBSC donors) and 4 weeks and 3 months after donation. The SF-36 is a generic indicator of HRQOL derived from the 245-item Medical Outcomes questionnaire. It includes multi-item scales to measure the following 8 dimensions: physical functioning (PF), role limitations due to physical health problems (RP), bodily pain (BP), general health perception, vitality, social functioning, role limitations due to emotional problems, and general mental health. Physical Component Summary (PCS) and Mental Component Summary (MCS) scores provide a broad physical and mental health perspective [17]. Norm-based scoring was used to interpret the different dimensions' and summary scores [17,18]. This scoring is created by computing the 0 to 100 score for a scale and then adjusting this score by the general population's average and standard deviation (SD) on that scale. As a consequence, the population mean and SD of all scores are 50 and 10, respectively, with higher scores reflecting more positive health states.

Statistical Analysis

The primary endpoints were time to recovery and individual side effects at different time points as defined earlier. Characteristics analyzed as potential influencing factors were the previously defined demographic factors and the PCS and MCS measures.

The probabilities of complete recovery were calculated using the Kaplan-Meier estimator, and groups were compared using the log rank test. PCS and MCS measures were split into 4 groups, based on the 25th, 50th, and 75th percentiles. Factors significant in univariate analysis at the ≤.20 level were entered into a stepwise proportional hazards regression analysis.

The influence of the previously defined demographic and HRQOL factors on individual side effects was examined using either a chi-square test, *t*-test, or Mann-Whitney U test. Binary summary scores were established for pain (headache, myalgia, back pain, and any other pain) and any side effect for each time point. In addition, summary scores for each side effect involving all time points from day 0 onward were established. Factors with $P \leq .20$ in the univariate analysis were included in a stepwise logistic regression analysis. Comparison between BM and PBSC donors was performed using the chi-square test for categorical variables and the *t*-test or Mann-Whitney U test for continuous variables.

Our secondary endpoint was to assess changes in SF-36 scores before, 4 weeks after, and 3 months after donation. Paired sample *t*-tests were used to compare the SF-36 scores before and after donation. Stepwise linear regression analysis was performed to identify significant variables that could be used to predict HRQOL (using PCS and MCS scores) at 4 weeks after donation.

All statistical analysis was performed using SPSS software (IBM, Armonk, NY). A 2-tailed $P < .05$ was considered significant.

RESULTS

Characteristics, Side Effects, and Recovery in BM and PBSC Donors

Table 1 shows clinical characteristics of BM and PBSC donors enrolled in the study. A central line was inserted in 5% of PBSC donors (2% of male donors compared with 15% of female donors; $P < .001$); 27% of PBSC donors (74/275) required a 2-day collection.

Figure 1 shows the time course and side effects experienced in PBSC donors. Pain in PBSC donors consisted mainly of bone pain and headache. Pain peaked during administration of G-CSF, with 85% of donors experiencing pain on the third day of G-CSF administration. The pain was graded as CTCAE 1 in 80% of cases, with only 1 donor experiencing grade 3 pain. Fatigue and bruising were the other most common side effects, peaking on days 2 and 3 after donation. Seventy-five percent of donors (207/278) required analgesia during G-CSF administration, and 2.5% of donors still required analgesia 7 days after donation.

All BM donors received general anesthesia. The mean duration of the procedure was 41 minutes (range, 20 to 120). The mean volume of BM harvested was 1209 mL (range, 290 to 1740). Autologous units were not collected, and no donor received an allogeneic transfusion. All except 1 were discharged the day after BM harvest. Figure 2 shows the time course and side effects experienced. Pain in BM donors was generally localized to the site of donation or the throat (after intubation). The peak of pain was reported on days 2 and 3 after donation for back pain (76.5%) and on the day of donation for throat pain (48.6%). Fatigue and bruising were the most common other side effects reactions, peaking on days 2 and 3 after donation. Most side effects were classified as CTCAE grade 1, and no donor experienced grade 3 or 4 side effects in this small cohort. Ten percent of BM donors (3/29) still required analgesia 1 week after donation.

The median time to recovery for BM donors was 10 days as opposed to 3 days for PBSC donors ($P = .001$) (Figure 3A). Only 50% of BM donors believed they had recovered after 1 week, and 68.8% had returned to work, compared with 90.3% and 98.3% of PBSC donors, respectively ($P < .001$). Compared with PBSC donors, significantly more BM donors still experienced pain ($P < .001$) and other side effects in general ($P < .001$) 1 week after donation.

Health-Related Quality of Life

The response rates for the SF-36 questionnaires for PBSC donors were 72% (198/275) before donation, 72% (199/275) 4 weeks after, and 72% (198/275) 3 months after donation. Fifty-eight percent of PBSC donors returned all 3 questionnaires. Nonparticipants were more likely to be younger ($P < .001$) and male ($P < .05$). There was no statistical difference between collection characteristics in those returning versus not returning forms. This included volume of blood processed, presence of a central line, and 1- versus 2-day collection.

The response rates for the questionnaires for BM donors were 75% (28/37) before donation, 59.5% (22/37) 4 weeks after donation, and 67.6% (25/37) 3 months after donation. Forty-nine percent of BM donors (18/37) returned all 3

Table 1
Donor Characteristics at Time of Donation for PBSC and BM Donors

Characteristic	PBSC		BM	
	n	%	n	%
Number of donors	275	88	37	12
Number of apheresis/ harvest centers	4		4	
Gender				
Male	209	76	34	89
Female	65	24	4	11
Ethnicity				
United Kingdom and Ireland	99	36	11	29
Europe (White)	160	58	23	61
Other (White)	4	2	1	2
Asian	3	1	0	0
African and Caribbean	2	.5	1	2
Mixed ethnicity	2	.5	0	0
Decline/unknown	4	2	2	6
Donor age at donation				
16-30 yr	122	44.5	21	55
31-40 yr	92	33.5	7	18
41-63 yr	60	22	10	27
Median (range)	30.9 (17-63)		27.9 (19-55)	
Donor BMI				
Underweight (<18.5)	3	1	0	0
Normal (18.5-24.9)	100	38	14	37
Overweight (25-29.9)	107	41	14	37
Obese (>30)	53	20	10	26
Median (range)	25.9 (17-41.6)		26.7 (19.7-33.9)	

questionnaires. There were no statistical differences between demographic factors and collection characteristics (duration of harvest, marrow harvested per unit of donor's weight) in those returning versus not returning forms.

Factors Affecting Time to Complete Recovery

PBSC donors

Factors associated with a more rapid recovery time in univariate analyses were a higher predonation PCS score ($P = .002$) (Figure 3B), younger age ($P = .003$), and male gender ($P = .027$). The mean time to complete recovery was 5.8 days (range, 0 to 30) for donors with predonation PCS scores ≤ 56 (lowest quartile) compared with 3 days (range, 0 to 21) for donors with scores > 60 (highest quartile). A difference in time to complete recovery was most significant when comparing the donors with scores in the lowest quartile with the other groups. When assessing the individual components of the PCS, higher PF ($P < .01$), RP ($P < .05$), and less BP ($P = .005$) were associated with a more rapid recovery. There was no significant association between BMI ($P = .99$), marital status ($P = .21$), being a blood donor ($P = .37$), predonation MCS score ($P = .29$), blood volume processed ($P = .65$), and recovery. Donors with fewer dependents showed a trend toward more rapid recovery compared with donors with more dependents ($P = .057$). When assessing the association between collection characteristics and a faster recovery, there was a trend toward significance for the absence of a central line ($P = .068$) and 1- versus 2-day collection ($P = .084$). The predonation PCS score was the only factor that remained significant in multivariate analysis ($P = .017$). Donors with a predonation PCS higher than 60 (highest quartile) had a relative risk of 1.6 (95% confidence interval [CI], 1.01 to 2.7) of achieving faster recovery compared with donors with scores ≤ 56 (lowest quartile).

BM donors

The only factor influencing time to recovery in univariate analysis was the predonation mental component summary score ($P = .046$) (Figure 3C); The mean time to complete recovery was 28 days (range, 4 to 56) for donors with predonation MCS scores ≤ 46 (lowest quartile) compared with 9.4 days (range, 2 to 21) for donors with scores > 58 (highest quartile). Again, this difference in time to complete recovery was most significant when comparing the donors with scores in the lowest quartile with the other groups. There was no significant association between gender ($P = .17$), age ($P = .42$), BMI ($P = .88$), number of dependents ($P = .31$)

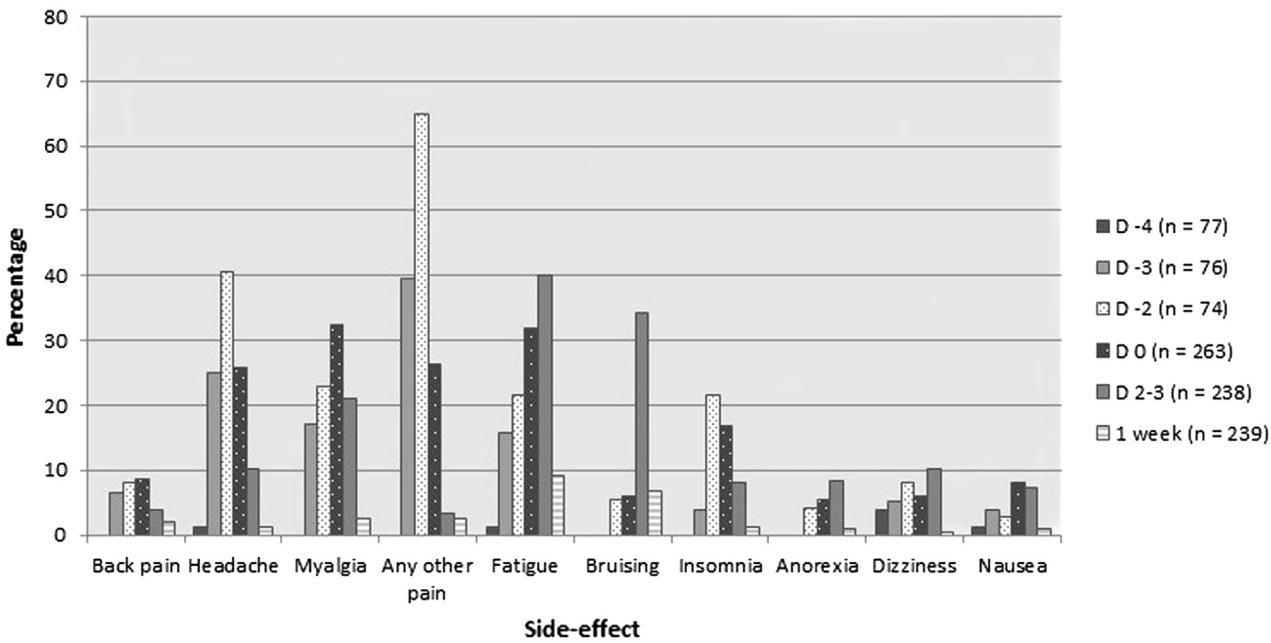

Figure 1. Frequency of common side effects after PBSC donation.

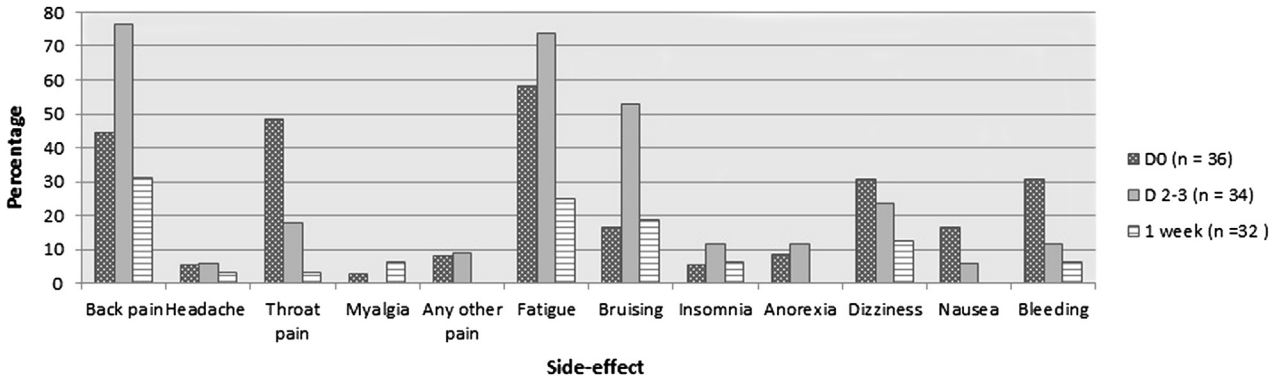

Figure 2. Frequency of common side effects after BM donation.

marital status ($P = .62$), predonation PCS score ($P = .51$), and time to recovery. Time of procedure ($P = .25$) and volume of harvest per kilogram recipient weight ($P = .95$) were not significantly associated with recovery. In multivariate analysis, predonation MCS scores ($P = .026$) remained significant. Donors with predonation MCS scores > 46 had a relative risk

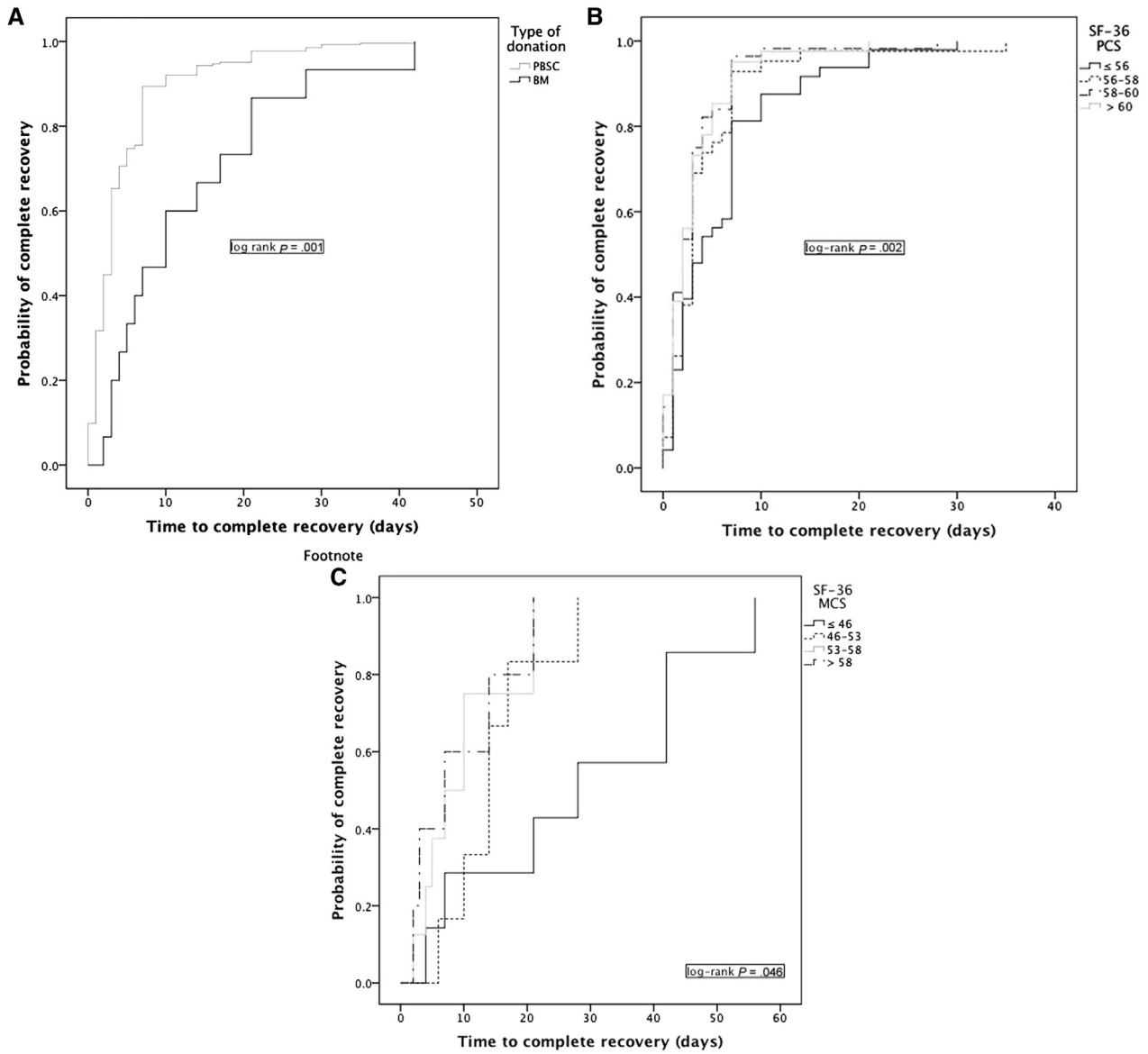

Figure 3. (A) Probability of self-reported complete recovery after PBSC versus BM donation. (B) Probability of self-reported complete recovery after PBSC donation, impact of the PCS score. (C) Probability of self-reported complete recovery after BM donation, impact of the MCS score.

Table 2
Changes in Predonation and Postdonation Scores

Type of Donation	Scoring Type	Mean of Difference Between Score at 4 Weeks and Baseline (Range)	*P*	Mean of Difference Between Score at 3 Months and Baseline (Range)	*P*
PBSC	PCS	−.92 (−14.9 to 13.2)	<.001*	.009 (−12.5 to 16.0)	.98†
	MCS	−.2 (−26.3 to 29.5)	.641	−.1 (−19.5 to 21.2)	.79†
BM	PCS	−5.02 (−18.4 to 8.6)	.009‡	−.3 (−12.2 to 9.6)	.71§
	MCS	−3.9 (−28.5 to 9.5)	.017‡	−1.2 (−21.0 to 7.4)	.37§

* Calculated comparing pairs with predonation and 4-week scores (n = 169).
† Calculated comparing pairs with predonation and 3-month scores (n = 151).
‡ Calculated comparing pairs with predonation and 4-week scores (n = 18).
§ Calculated comparing pairs with predonation and 3-month scores (n = 23).

of 3.7 (95% CI, 1.2 to 11.4) of achieving faster recovery compared with donors with scores ≤ 46 (lowest quartile).

Multivariate Analysis of Factors Affecting Individual Side Effects at Different Time Points in PBSC Donors

Physical component summary

Donors with predonation SF-36 PCS scores in the lowest quartile were more likely to experience fatigue (odds ratio [OR] 4.7; 95% CI, 1.8 to 12.7; $P = .002$) or any side effect (OR 3.0; 95% CI, 1.1 to 8.5; $P = .03$) on days 2 and 3 compared with donors with PCS scores in the highest quartile. They were also more likely to experience pain at any time point (OR 5.6; 95% CI, 1.8 to 17.6; $P < .005$).

Mental component summary

Donors with a predonation MCS score in the lowest quartile were more likely to experience pain at any time point compared with donors with scores in the highest quartile (OR 2.8; 95% CI, 1.1 to 7.1; $P = .003$). Dizziness at any time point was also more common in donors with lower MCS scores (OR 2.3; 95% CI, 1.01 to 5.5; $P = .003$).

Changes in SF-36 Score from Predonation Through 4 Weeks and 3 Months Postdonation

As indicated in Table 2, PCS scores declined significantly from predonation to 4 weeks postdonation ($P < .001$), with a return to predonation values at 3 months. This was shown both for PBSC and BM donors, but the decline in PCS scores was much greater for BM donors (Table 3). At 4 weeks after donation, the PF ($P = .001$), PR ($P < .001$), and BP ($P = .002$) subscores were lower for BM donors compared with PBSC donors. Mental summary score did not change throughout donation for PBSC donors but was significantly lower at 4 weeks for BM donors ($P < .01$); this returned to normal levels at 3 months.

The most significant subscore change in PBSC donors was for the RP score with a mean difference between the 4-week score and predonation of −1.6 ($P < .001$). The most significant subscore changes in BM donors were within the physical scores with a mean difference between the 4-week and predonation score of −7.8 ($P = .004$) for RP, followed by a mean difference of −5.8 ($P = .021$) for BP and a mean difference of −1.5 ($P = .049$) for PF. The most significant difference between the predonation and 4-week score within the mental scores in BM donors was for vitality scores, with a mean difference of -8.1 ($P < .001$), followed by a mean difference of -6.0 (P=.001) for SF.. There were no changes in general health perception ($P = .27$), emotional problems ($P = .074$), or general mental health score ($P = .42$).

Factors Predicting Physical and Emotional Health 4 Weeks after PBSC Donation

Based on the finding that HRQOL is significantly affected 4 weeks after donation, we aimed to clarify whether we could establish predictive factors for PCS and MCS scores 4 weeks after donation using multivariate linear regression analysis. We found no demographic factors were predictive of HRQOL after donation. Only a lower predonation PCS (coefficient β .64; 95% CI, .44 to .84; $P < .001$) and experiencing any kind of pain 2 and3 days after donation (coefficient β −1.721; 95% CI, −3.2 to −.2; $P = .03$) were associated with lower PCS outcomes at 4 weeks in PBSC donors. Explanatory variables included gender, age, BMI, number of dependents, marital status, being a blood donor, predonation PCS score, any side effect on days 2 and 3 summary score, and any pain on days 2 and 3.

Similarly, a lower predonation MCS score (coefficient β .71; 95% CI, .53 to .87; $P < .001$) and experiencing any kind of

Table 3
General Health Questionnaires in BM versus PBSC Donors

Time Point	Dimension	BM Mean	PBSC Mean	*P*
Predonation	PF	56.0	56.8	.13
	RP	56.7	56.5	.61
	BP	58.4	57.0	.28
	General health perception	56.7	57.8	.42
	Vitality	54.2	55.5	.42
	Social functioning	54.6	55.9	.11
	Role limitations due to emotional problems	52.8	54.8	.07
	General mental health	52.6	54.6	.08
	PCS	58.3	57.5	.29
	MCS	52.0	54.1	.24
4 weeks after donation	PF	47.0	52.9	.001
	RP	41.9	50.9	<.001
	BP	44.1	53.1	.002
	General health perception	48.5	53.6	.14
	Vitality	42.4	51.2	.01
	Social functioning	42.5	51.8	.001
	Role limitations due to emotional problems	43.1	51.4	.007
	General mental health	45.0	51.2	.32
	PCS	45.1	51.8	.003
	MCS	42.4	49.1	.34
3 months after donation	PF	56.1	56.2	.90
	RP	56.7	56.0	.27
	BP	58.2	58.3	.93
	General health perception	58.2	57.2	.57
	Vitality	55.9	54.8	.55
	Social functioning	54.1	54.7	.74
	Role limitations due to emotional problems	53.0	54.8	.12
	General mental health	54.1	54.1	.98
	PCS	58.2	57.8	.64
	MCS	52.6	53.6	.47

pain 2 and 3 days after donation (coefficient β −2.2; 95% CI; −4.3 to −.18; $P = .01$) were associated with lower MCS outcomes at 4 weeks. Explanatory variables included gender, age, BMI, number of dependents, marital status, being a blood donor, predonation MCS score, any side effect on days 2 and 3 summary score, and any pain on days 2 and 3.

DISCUSSION

Voluntary donation of BM or PBSC for hematopoietic cell transplantation is a well-established altruistic act, performed by thousands of healthy related or unrelated donors throughout the world. Although allogeneic stem cell donation is a safe procedure with very low rates of serious adverse reactions, some risk exists, and every effort should be made to minimize this.

In this prospective study, we found that predonation HRQOL markers were the most important factors associated with recovery and the development of side effects, more so than any demographic variable. To our knowledge, no studies have addressed the impact of predonation HRQOL on the donation experience in hematopoietic stem cell donors. The response rates of predonation HRQOL questionnaires were very acceptable (72%) in this study and better compared with another study in this field using the SF-36 questionnaire (60%) [19]. Response rates of a more recent study from Switzer et al. [20], however, were better compared with our study (99%), likely because the study methodologies differed.

The SF-36 questionnaire is the most widely used health status assessment tool in clinical trials [21]. The reason for choosing the SF-36 over the SF-12 or SF-8 questionnaire, which are shorter surveys and can be completed quicker, is because more items permit better precision and representation of each health domain [22].

The importance of PCS and MCS was demonstrated with quartiles providing cut-points. If treated as continuous variables, significant results were also obtained (data not shown). A lower predonation PCS score was the main factor associated with recovery for PBSC donors in multivariate analysis. Three scales (PF, RP, and BP) correlate most strongly with the physical component and contribute most to scoring of the PCS measure. Lower PCS scores indicate more limitations in PF, RP, a higher degree of BP, and poorer self-reported general health. Interestingly, mean predonation PCS scores were well above the mean of the general population (+.76 SD; $P < .001$), reflecting the strict medical assessment of donors. Examples of reasons for lower predonation PCS scores in this cohort included mild limitations to perform work or vigorous activities or having a history of mild or moderate bodily pains. Despite these mild limitations, lower predonation PCS scores were associated with a slower recovery. Experiencing very common side effects, such as pain and fatigue, were also associated with a lower predonation PCS score.

Lower predonation MCS scores were associated with an increased likelihood of experiencing pain in PBSC donors. Similar to the PCS scores, mean predonation MCS scores were above the mean of the general population (+.41 SD; $P < .001$). For the MCS measure, a lower score is indicative of more frequent psychological distress, social and role disability because of emotional problems, and poorer general health. Examples of reasons for lower predonation MCS scores in this cohort included feeling nervous, downhearted, or worn out a lot of the time. A negative association between mental or emotional health and an altered pain experience has been described previously [14,15,23-28]. Moreover, psychosocial interventions are often part of a multimodal approach of the management of pain [28], and negative mood has emerged as a strong and reliable predictor of postoperative outcomes [26].

We found similar results in our BM cohort; a lower predonation MCS score was the most important factor associated with delayed recovery. A possible explanation of the finding that MCS scores predicted recovery in BM donors but not in PBSC donors may be related to the very distinct nature of the 2 procedures. Because BM donation was associated with pain symptoms at later time points, we speculate that preexisting symptoms of anxiety or low mood would have a significant impact on this outcome.

When examining the evolution of HRQOL during the donation process, we found a decrease in general health for BM and PBSC donors at 4 weeks with a return to normal levels 3 months after donation. The 3-month values were well above the mean of the general population (+.79 SD for PCS and +.34 SD for MCS; $P < .001$). Most scores at 4 weeks were significantly lower for BM donors compared with PBSC donors, reflecting a delayed recovery compared with PBSC donors [4,6,19,29,30]. We did not find improved mental or physical scores after donation, as described in a recent study [20]. This may be related to the different time points assessed; improved physical and mental scores were described at 6 and 12 months after donation. We may have possibly observed a similar trend if we had continued assessments at these time points.

To the best of our knowledge, this is the first study to show that even in PBSC donors, physical health is significantly (although minimally) reduced 4 weeks after donation compared with predonation. The strongest decrease was within the RP subscore. The RP scale covers an array of physical health-related role limitations, including limitations and reductions in the amount of time spent at work or other activities (such as sports). There were no significant changes in MCS scores during the donation process for PBSC donors, as opposed to BM donors. The main MCS subscore affected in BM donors was the vitality score. These findings may reflect an association between physical morbidity and vitality and are in keeping with a delayed physical recovery in BM versus PBSC donors. Despite considerable pain in BM donors, mental health scores remained high, indicating that donors did not feel distressed by pain. This had also been previously reported [31]. In view of these findings, we would recommend the donor experience to be a serious consideration when deciding on the stem cell source, especially if there is no specific patient indication for a BM source.

Based on the finding that HRQOL was significantly decreased at 4 weeks, we aimed to predict which side effects were associated with poorer outcomes. We found that experiencing pain on days 2 and 3 was a significant predictor of general physical and mental health at 4 weeks after donation in PBSC donors, regardless of predonation physical and mental health. This information could be very valuable to monitor this high-risk group more closely.

However, certain limitations in our study must be acknowledged: The SF-36 only captures part of overall HRQOL, and a more comprehensive psychological assessment tool or formal qualitative interview process must be the focus of future studies. Also, we included a limited number of BM donors, which limited the analysis in this group. For example, the number of BM donor participants was too small to analyze the factors affecting individual side effects at different time points and to assess the factors

predicting physical and emotional health 4 weeks after donation, 2 analyses that were performed in our PBSC cohort.

In conclusion, we found that predonation quality of life markers contribute significantly to recovery and toxicity profile after BM or PBSC donation. We believe our findings may help clinicians identify donors at risk for poorer outcomes. HRQOL questionnaires such as the SF-36 are highly standardized, and their introduction at the time of donor medical evaluation should be considered to establish which donors are at risk of delayed recovery. The findings of this study may help clinicians provide donors with a targeted guidance protocol. Possible interventions for high-risk donors may include the use of preemptive analgesia, an approach that has proven effective in BM donors [32] and general surgery patients [33,34]. Preoperative patient education has also demonstrated improved recovery times in surgery [35,36]. These approaches, as well as a more stringent follow-up of high-risk donors, need to be examined in the future.

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